

2.4.0

SERIES 2
Understanding
Vulnerability & Risk



CLIMATE CHANGE, EXPOSURE & RISK

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One component of vulnerability to climate hazards is exposure, literally putting people, infrastructure, and assets in areas where hazards occur. Climate change is affecting the intensity, frequency, and in some cases, location or nature of climate hazards. This set introduces climate change and its potential future impacts, examines current climate exposure, and explores potential future climate risk. The set assumes a basic understanding of the causes of climate change, global climate models, and the sources of uncertainty in model results.

IN THIS SET YOU WILL:

- ✓ Be introduced to climate change and its potential future impacts;
- ✓ Examine your historic climate exposure; and
- ✓ Explore potential future climate exposure and hazards and how they combine to form climate risk.

Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has significant evidence that the use of fossil fuels, deforestation, and changes in land use have led to an increase in greenhouse gases (GHGs) in the atmosphere, causing the Earth's surface temperature to rise. This has already and will continue to result in:

Increased temperatures: temperatures are increasing globally. Temperatures on land, particularly in inland locations, are likely to increase more than temperatures over the oceans or near coasts. Cold season and nighttime temperatures may increase more than warm season and daytime temperatures.

Rising sea levels: sea levels are rising in response to increased temperatures. Higher temperatures cause the oceans to expand as they warm and melt land-based ice, increasing the amount of water in the oceans. Sea level rise is likely to accelerate over the next 100 years regardless of greenhouse gas emissions.

Changes in precipitation timing and intensity: in general, dry regions and dry times of the year are likely to get drier, and wet regions and wet times of the year

are likely to get wetter. When rain falls, it is likely to fall as more intense rainstorms.

Increased melting of snow and ice: in areas that experience freezing, precipitation will fall increasingly as rain rather than snow, snowpack will melt earlier, and glaciers will melt faster and at increasingly higher elevations.

Weather will become more variable: climate hazards (typhoons, flooding events, extended droughts, and heat waves) are likely to occur more often and may be more intense than past events.

The impacts of these changes in the climate system are likely to include:

- Increasing energy demand for cooling during hot weather events;
- Increased difficulty in meeting water demand during dry periods;
- Increased salinization in estuaries and near river mouths, and possible increases in salinization of near-coastal groundwater reserves;
- Changes in agriculture and fisheries;
- Inundation of coastal and delta areas;

- Spread of respiratory, vector, and water-borne diseases; and,
- Population displacement.

These events will dramatically alter ecosystems and the lives and livelihoods of women, men, and children. Countries such as Indonesia, Vietnam, and Bangladesh, with heavy concentrations of population and economic activity in fragile and vulnerable regions such as coasts, deltas and low-lying areas, are especially threatened by climate change.

Urban areas, already stressed by disasters such as storms and flooding, are particularly vulnerable to climate impacts. Climate impacts will stress physical, built-infrastructure such as transportation, communication, and water delivery systems, increase energy demand, and affect economic sectors such as agriculture, fisheries, and tourism. Impacts may be exacerbated by inadequate infrastructure and housing, limited access to services, limited urban planning and land-use management, and limited preparedness among city populations and emergency services. Urban poor are especially at risk due to location of settlements in areas vulnerable to floods and landslides, limited access to services such as water, energy supply and health, and few assets or safety nets that enable them to manage loss. Women, who often have less access to services or economic resources, are particularly vulnerable. Already urban governments are strained to deliver services and manage impacts of disasters.

Rapid urbanization and population increase, as is occurring in much of the developing world, places additional stresses on urban infrastructure and ecological systems and on the ability of cities to manage climate change impacts.

Climate Exposure

Disaster risk reduction practitioners often note “natural hazards happen, but natural disasters are created”. This is because it is only when groups of people, systems, and infrastructure in our cities are put in places where natural hazards occur, and when they are left vulnerable to those hazards in those places, that they suffer harm. Historically, cities have grown and developed next to rivers or along coastlines because water is necessary for sustaining a city and integral to economic activities. However, by situating our cities in these locations and altering waterways and ecosystems through land use development, we expose ourselves to numerous climate hazards, including flooding, drought, typhoons, storm surge, and high tides.

How much harm we suffer from a particular climate hazard is determined by our vulnerabilities and our capacities and to a lesser extent, by the intensity and frequency of hazard events to which we are exposed. For example, the poor and socially marginalized often lack the money or social

resources to secure good housing and instead are often left to live in slums or migrant housing communities in low lying areas. The buildings they live in are poorly constructed and easily damaged by wind or water and the location itself often floods. In cases such as this, the “exposure” of these groups is due more to social constraints and resource access than the climate hazards, which, with adequate resources, could be significantly avoided. Similarly, the least expensive land is often located in hazard-impacted areas like floodplains. Governments, seeking to save money on public infrastructure projects, may be tempted to locate critical infrastructure such as schools, water treatment plants, hospitals, and major transportation routes in these areas. However, building in these areas comes with a higher risk due to the high exposure.

Climate hazard mapping is a simple way to explore your climate exposure. Mapping areas historically impacted by climate hazards provides a quick means of visualizing which groups of people, critical infrastructure such as hospitals or electricity generation plants, or areas of your city are more likely to experience hazards. Climate hazard mapping can help you identify flood plains, areas where landslides or wildfires are more likely to occur, and areas of likely storm surge. This knowledge can be used in city planning efforts. Ideally, people and infrastructure will not be situated in the highest-hazard areas; either hazards will be mitigated, or

multiple resilience measures will be incorporated into the development plans. For example, in Thailand a new hospital for the elderly near Bangkok is being constructed on 400 stilts to raise it 15 feet above ground level, mitigating floodrisk.

Climate Risk

The Bangkok exposure mapping case study—see text box—highlights one of the challenges that climate change is going to pose; the location and nature of climate exposure will change as climate changes. This means that climate risk will change.

Climate risk is an estimate of the likelihood of a climate hazard exceeding a critical threshold and causing an impact to a particular group of people, an area of your city, or a city system as a result of that group’s, area’s, or system’s underlying vulnerability or fragility.

Current and historical climate risk can be quantified with sufficient data. To assess current climate risk, we can use historical data about the hazard—its intensity and how frequently it occurs—to calculate the likelihood of future events of that size. Next, we describe how confident we are in the historical data (how much we believe the data). This



CASE STUDY Climate Hazard Mapping

Bangkok is a low-lying city located in the Chao Phraya river delta, at the bottom of a 160,400 km² drainage basin. Much of the city lies only slightly above sea level. Average flow in the Chao Phraya is 718 m³/s, but during and following the summer monsoons, flows can reach 6000 m³/s. Large areas of the city are exposed to flooding during heavy precipitation events, during peak river flows, and particularly when high flows coincide with high tides. Figure 2.4.1 is a flood risk hazard map for the city showing the relative exposure of various areas of the city to flood. Many of the industrial areas, a World Heritage site that is a significant tourism draw (Ayuttaya) and the domestic airport, are all located to the north and north-east of central Bangkok, areas which fall in the Level 2 (high) and Level 3 (highest) flood risk zones. In 2011, Bangkok was subject to major flooding due to record high flows coupled with high tides. During the floods, the northern sections of the city were underwater for over a month, closing down the domestic airport and many industrial factories. This had enormous impacts not only on the Thai economy, but also on the global economy. Future sea level rise of 30 cm, which is projected to occur by 2050, will significantly increase inundation depth and duration in the city and expand the size of the Level 2 and Level 3 risk zones unless significant actions are taken by the Thai.

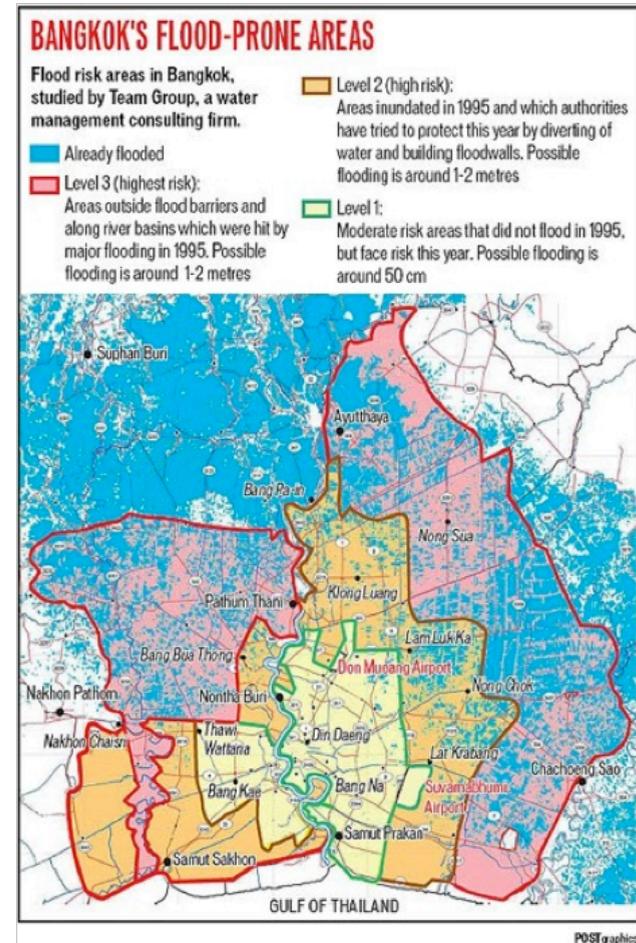


Figure 2.4.1 Flood hazard map of Bangkok, Thailand published during the 2011 flooding.

will depend, in part, on whether we have a long record of past data, or a very short record, and on how accurate we think the data itself is. Finally, we combine the likelihood of hazard occurrence with the severity of impacts, and a description of our confidence in the data, and then use this to describe the level of current risk associated with that hazard for a particular group of people or city system. Once hazard risk is described (qualitatively or quantitatively), it can be used to test out various resilience plans and options to see if the risk is reduced or increased by a particular option or development trajectory. Risk estimates are also used, for example, by city planners to determine zoning, building codes, and other safety measures, and by insurance companies to determine whether, and if so at what cost, they will insure various assets.

Climate change, however, is already changing the type of climate hazard events that occur, their frequency, and their magnitude. This means that identifying the risk of future climate hazard events is going to become increasingly uncertain. Climate change may also result in new climate hazard events. For example, already in various global locations we are seeing impacts of extreme heat events such as road damage due to heat-melting or expansion, railway damage due to rail expansion and buckling, and foundation damage due to extreme soil heating and drying. Similarly, climate change is anticipated to have an impact on concrete

structures through increasing rates of deterioration as well as through the impacts of extreme weather events (Wang et al., 2010).

This is why we focus on building resilience rather than addressing individual climate hazards. It is going to become increasingly difficult to provide the climate information necessary to support design specifications for dams, dikes, flood control channels, and so forth. There are techniques that allow more precise identification of potential climate changes at a given location, such as downscaling global results to provide information at a much smaller, more local scale. Clearly, for major infrastructure development, this is necessary to quantify, as best we can, the nature and magnitude of potential climate changes. In some cases, however, unresolvable uncertainty may lead planners and engineers to find alternative design approaches that are less dependent on climate specifics. And, for most planning and non-structural resilience actions, the broad climate change information available from global circulation models is enough to begin to act. By building resilience, rather than attempting to engineer solutions to a rapidly changing climate, your city will also far better prepare itself for the unexpected.

How to Use Climate Projections in Your Resilience Building Process

First, try to obtain the best future climate data available for your location. There is a great deal of information available about climate both globally and regionally, and the more accurate picture you can get about possible climate changes at your location, the better. You and your facilitator should look, at the national and regional level, for climate modeling organizations and begin a dialogue with them about how they can support your process. In many cases, donor agencies, climate or disaster focused NGOs, and local or national meteorological offices may also be able to provide suggestions for where to look for future climate data.

As you look for future climate data, there are three key things to remember about what you need and how you should use it:

First, the data you obtain are not predictions. The data do not tell you what the future climate will be like. Instead, what you have obtained are “projections,” a statement about what might happen in the future. So, even if the data indicate a 2°C increase in winter temperature in 2040, that doesn’t make it a planning target.

Second, climate scientists cannot project future climate accurately. There are currently about 30 global circulation models producing results for 6 different possible future conditions (called “scenarios”). Each model produces slightly different results for each scenario, and we have no reason to believe one model or scenario is more likely than any other model or scenario. Ideally, when you are given climate data, it will be based on results for several models, will provide results for two or more scenarios, and will give a range of possible future conditions for each scenario (e.g. temperature increases of 2.3 to 3.5 °C by 2050 for the A2 scenario). If you are just given a single number, be aware that the values you are looking at represent the mid-point of what may be a fairly large range. Although the data you receive might project an increase in wet season rainfall in 2040 of 3%, the full range of models and scenarios might actually project changes ranging from an increase of 20% to a decrease of 10%.

Third, whatever data you are given will not reflect the increase in variability that future climate is likely to have. For example, even if you are given a range of possible rainfall changes, only very specialized climate data would address how intense the rainstorms will be that deliver that rain. You will probably be given, at best, monthly future climate information

for a particular point in time, such as 2040. This provides little guidance about how daily high or low temperatures could change or what individual storms might look like.

Ideally, when you obtain your climate data, you will obtain it from a source that you can have an ongoing discussion with. If this is the case, begin building a relationship with your climate data provider. Ask what scenarios the data represent, and whether it is from multiple models or just one. And, see if they will engage directly with your resilience building effort. Climate scientists typically distribute climate information in ways that are easy for them to produce, and this is rarely in a form that is particularly useful for city resilience planning. If you can teach your climate data provider about the types of climate data you need to support building resilience on the ground in your city, both you and they will benefit.