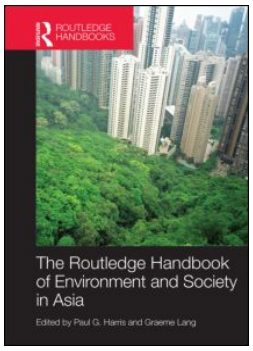
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21

Vulnerabilities to climate change

Adaptation in the Asia-Pacific region

Benjamin K. Sovacool

Introduction

Climate change is a substantial security concern not only because direct flooding and natural disasters can damage infrastructure, disrupt the delivery of imported commodities, and destroy crops, but also because it can have severe impacts on food security and nutrition, health, and environmental refugees, which can all lower the income base of Asian countries and add to government debt, further complicating attempts at sound policymaking. Under a business as usual scenario, the IPCC forecasts that emissions of all greenhouse gases will rise from 52.5 billion tons today to 140 billion tons by 2100 – almost a threefold increase, and also a trend discussed in other chapters in this book. The atmospheric concentration of carbon dioxide reached 396 parts per million (ppm) in 2012 and 407 ppm when all greenhouse gases are accounted for, and will rise to 1,410 ppm for all gases by 2100 under business as usual. Depending on assumptions and particular models, such emissions and concentrations could result in a temperature change of 4.81° Celsius by 2100.

Although climate change is certainly a global phenomenon, in many ways it is becoming an Asian problem. Figure 21.1 shows annual tons of carbon dioxide emissions from fuel combustion divided by total national population for selected Asian countries, and it indicates emissions have more than doubled from 1990 to 2010 for countries such as Cambodia, Indonesia, Malaysia, Myanmar, Thailand, Vietnam, and China. Figure 21.2 also indicates that when changes in land use are included, five of the top 10 emitters of greenhouse gases – China, Indonesia, Russia, India, and Japan – already reside in Asia.

Unfortunately from a climate standpoint, the greenhouse gases *already* emitted will threaten Asian countries with a staggering list of negative consequences. But how do these impacts differ in scale and scope? Which countries are more vulnerable than others? And, lastly, how ought they best respond and adapt to the impacts of climate change?

Asia's vulnerability to climate change

Because the Asia-Pacific region is home to a diverse mix of countries with different geographic, economic, political, and cultural traits, and because vulnerability is conditioned by both the

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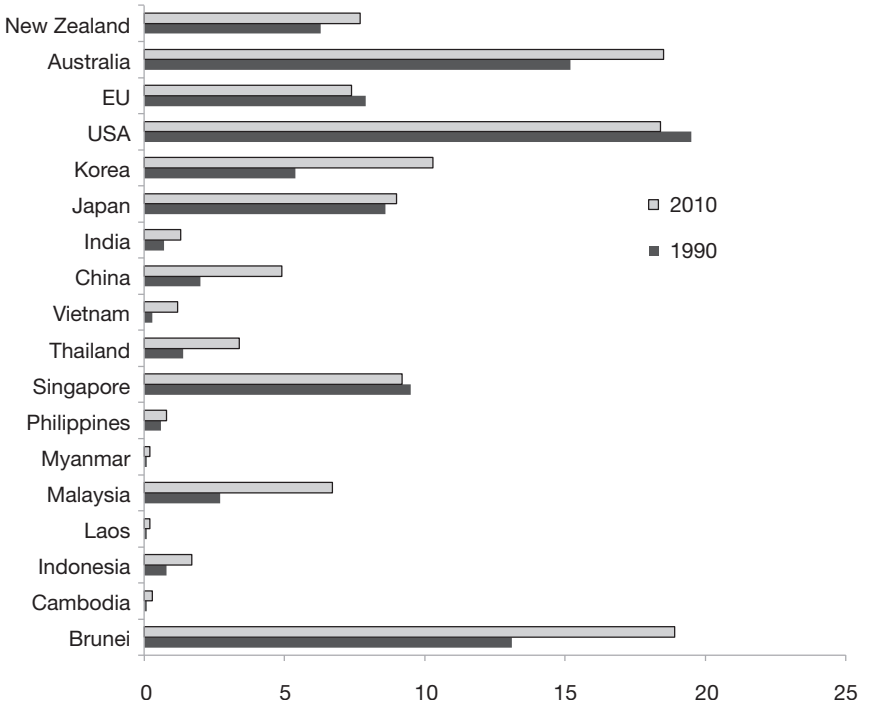


Figure 21.1 Per capita energy-related carbon dioxide emissions (metric tons), 1990 and 2010
Source: Sovacool et al. (2011).

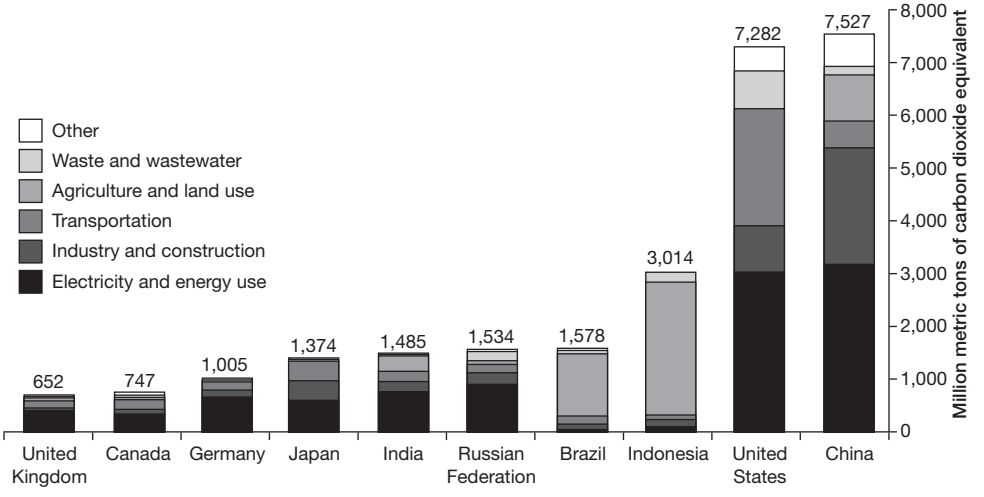


Figure 21.2 Share of greenhouse gas emissions by top 10 countries, 2010
Source: Brown & Sovacool (2011).

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nature of a threat and the resilience of those experiencing it, each Asian nation will experience climate change differently. For instance, because of their unique climatology, low per capita incomes, and changing patterns of urbanization, Indonesia, the Philippines, Thailand, and Vietnam are expected to lose 6.7 percent of combined gross domestic product (GDP) by 2100 if temperatures change as the IPCC predicts, more than twice the rate of global average losses (Asian Development Bank 2009). Even uniform changes in climate will not affect Asian countries equally, with Cambodia, Laos, the Philippines, Mekong River Delta, central Thailand, and Sumatra and Java in Indonesia more at risk than wealthier countries such as Brunei or Singapore (Singapore Ministry of the Environment and Water Resources 2008; Yusuf & Francisco 2009).

China and India would see a potentially larger range of impacts. They could lose between 1 and 12 percent of their annual GDP coping with climate refugees, changing disease vectors, and failing crops (CNA 2009; Economics of Climate Adaptation Working Group 2009; RUSI 2009). One study forecasts a 37 percent reduction in national crop yields by 2050 in China if current climate trends continue (McMichael 2007). Some states, such as Maharashtra, India, are projected to suffer greater drought that will likely wipe out 30 percent of food production, inducing $7 billion in damages among 15 million small and marginal farmers (Economics of Climate Adaptation Working Group 2009). In India as a whole, farmers and fishers will have to migrate from coastal areas as sea levels rise and they confront heat waves lowering crop output and manage declining water tables from saltwater intrusion (CNA 2009).

Bangladesh is prone to a multitude of floods, droughts, tropical cyclones and storm surges. Fifteen percent of its 162 million people live within one-meter elevation from high tide. In 1991, a particularly devastating cyclone with winds stronger than 200 kilometers an hour and a tidal surge of 6 meters claimed 140,000 lives and induced $240 million in damages (Asian Development Bank 2005a). Such climatic vulnerabilities are only compounded by a high incidence of poverty and heavy reliance on agriculture and rural forestry. Studies have found that rising sea levels could place more than 40 million Bangladeshis at direct risk of saltwater intrusion of water supplies for drinking and irrigation, and the ever present occurrence of floods from drainage congestion and severe storms (Government of Bangladesh 2009; Government of Bangladesh and United Nations Development Program 2008). During the monsoon season in 2004 in Bangladesh, for example, flooding placed 60 percent of the country under a solid pool of water mixed with industrial and household waste. More than 20 million people suffered shortages of water, skin infections, and communicable illnesses (Rawlani & Sovacool 2011).

In Bhutan, the acceleration of glacial melting has compounded the risk of glacial lake outburst floods (GLOFs). Glacial lakes there hold tens of millions of cubic meters of water and can release high volumes in minutes, devastating valleys and communities downstream. Major sectors of the economy involve agriculture, livestock, and forestry, but these have become situated in close proximity to flood paths. One inventory identified 25 glacial lakes at 'high risk' of a GLOF with 12 located in the Pho Chhu and Chamkhar Chu sub-basins, home to more than 40 Bhutanese villages and towns with tens of thousands of residents (Dorji et al. 2001; National Environment Commission, Royal Government of Bhutan 2008). Melting glaciers could flood river valleys in Kashmir and Nepal to the point where more than 180 million people could be at risk from the flooding and from subsequent epidemics and starvation (Brown & Sovacool 2011).

In Cambodia, droughts and floods have already caused substantial human and crop losses and are widely viewed as a prelude to more extreme weather. Rice, Cambodia's largest crop by volume and value, is forecasted to suffer yield losses of 5 percent over current levels in 2020 under IPCC scenarios. Annual rainfall is projected to increase in some areas, but when coupled

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with increased variability and ambient temperatures, yield losses will worsen through 2080 and potentially turn Cambodia into a net rice importer (Cambodian Ministry of Environment 2006; Ponlok 2009).

Geographic and geophysical traits, such as its small size, low elevation, narrow width, and dispersed nature of coral islands and reefs make the Maldives especially vulnerable to rainfall flooding and ocean-induced flooding. About half the country's human settlements are within 100 meters of the shoreline, along with almost three-quarters of its critical infrastructure, including airports, power plants, landfills, and hospitals. The Maldives is the 'flattest country on earth' and 'extremely vulnerable' to climate change, so much so that 85 percent of its geographic area could be underwater by the year 2100 if sea levels rise under more extreme projections (Khan et al. 2002). Severe weather events from 2000 to 2006 already flooded 90 inhabited islands at least once and 37 islands repeatedly. Sea swells in 2007 inundated 68 islands in 16 atolls, destroyed 500 homes, and necessitated the evacuation of 1,600 people (Sovacool 2011, 2012a, 2012b).

Complicating this picture is the issue of water availability and climate change, which is slowly but steadily altering precipitation and water patterns. For instance, if global warming induces the rise in sea level that many climatologists and scientists expect, the intrusion of saltwater could contaminate freshwater aquifers – possibly reducing worldwide potable water supplies by 45 percent (Smith & Ibakari 2007). Warmer temperatures resulting from global climate change will also increase energy demands in urban areas and require more intensive air-conditioning loads, in turn raising the water needs for power plants. Hotter weather also increases the evaporation rates for lakes, rivers, and streams, and thus accelerates the depletion of reservoirs, and causes more intense and longer lasting droughts as well as more wildfires – which in turn need vast quantities of water to fight and control them (Sovacool & Sovacool 2009).

Another extremely negative trend is the acidification of the ocean, which will threaten Asian fish stocks and coral reefs. Scientists expect the greatest degree of ocean acidification, caused by greenhouse gas emissions, to occur in the Atlantic, Pacific, and Arctic seas, each crucial summer feeding grounds for billions of organisms, and each home to fish that migrate across the Asia-Pacific (Carrell 2009). Recent scientific studies warn that climate change will likely lead to numerous local extinctions and drastic species turnovers (removal and/or extinction from an area) affecting more than 60 percent of all marine biodiversity, as well as declines in the vitality of coral reefs due to bleaching, diseases, and tropical storms – with roughly one-third of all coral reefs at risk of becoming extinct (Gosling et al. 2011). If allowed to run its course, such acidification could turn the shining seas surrounding Asia (and, indeed, other continents) into a 'carbon cesspool' (Lamirande 2011).

Although these vulnerabilities are great, perhaps the most severe climate change impacts will befall small island developing states. Small island countries in the Pacific sit at the ever present mercy of natural disasters, especially cyclones and storm-induced floods that can damage energy infrastructure and lower national incomes. Figure 21.3 shows that since the 1950s, the quantity and magnitude of natural disasters throughout the Pacific have increased significantly. Table 21.1 also illustrates that a selection of Pacific island countries have had no fewer than 257 disasters from 1950 to 2008, which have caused $6.8 billion in damages (Asian Development Bank 2005b; World Bank 2009).

In the Solomon Islands, the Ministry of Environment, Conservation and Meteorology has warned that 'energy production, utilization, conversion and transportation' have and will continue to be negatively affected by 'droughts, floods, fires, storm surges, and cyclones' (Ministry of Environment, Conservation and Meteorology 2008). In Samoa, the earthquake and tsunami in September 2009 greatly damaged the Electric Power Corporation's (EPC) generation and distribution assets in the southern and eastern coastal areas of Upolu, Manono, and Savii. Damages included toppled power poles and fittings, cracked transformers, and destroyed hydroelectric dams (Electric Power Corporation 2010). With assets of only $163 million (hardly enough to

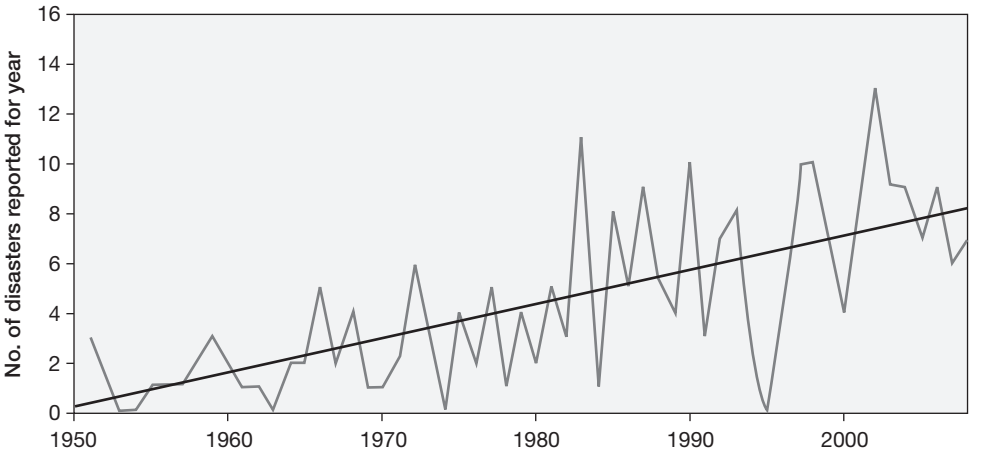


Figure 21.3 Number of natural disasters reported in the Pacific Islands Region, 1950–2008
Source: World Bank (2009).

Table 21.1 Estimated economic and social impact of disasters in selected Pacific Island countries, 1950–2008

Country	*No. of disasters*	*Losses (US$ 2008)*	*Average population affected (%)*		*Average impact on GDP (%)*	
			Disaster years	*All years*	*Disaster years*	*All years*
American Samoa	6	237,214,770	5.81	0.61	7.76	0.82
Cook Islands	9	47,169,811	5.13	0.63	3.48	0.43
Fiji	43	1,276,747,934	5.39	2.74	3.48	0.78
French Polynesia	6	78,723,404	0.53	0.04	0.31	0.02
FSM	8	11,915,993	6.20	0.65	0.82	0.09
Guam	10	3,294,869,936	1.97	0.28	10.13	1.42
Kiribati	4	0	29.19	1.54	0.00	0.00
Marshall Islands	3	0	6.40	0.22	0.00	0.00
New Caledonia	15	69,623,803	0.14	0.03	0.09	0.02
Niue	6	56,461,688	73.15	7.70	80.88	8.51
Papua New Guinea	58	271,050,690	0.69	0.36	0.14	0.07
Samoa	11	930,837,187	21.15	3.71	16.97	2.98
Solomon Islands	21	39,215,686	2.93	0.98	0.52	0.17
Tokelau	4	4,877,822	39.70	2.79	N/A	N/A
Tonga	12	129,344,561	21.32	3.37	5.76	0.91
Tuvalu	5	0	3.19	0.28	0.00	0.00
Vanuatu	36	406,402,255	5.33	2.06	3.78	1.46

Notes: The term 'natural disasters' includes droughts, earthquakes, epidemics, floods, landslides, severe storms, volcanic eruptions, wave surges and wildfires.

Source: World Bank (2009).

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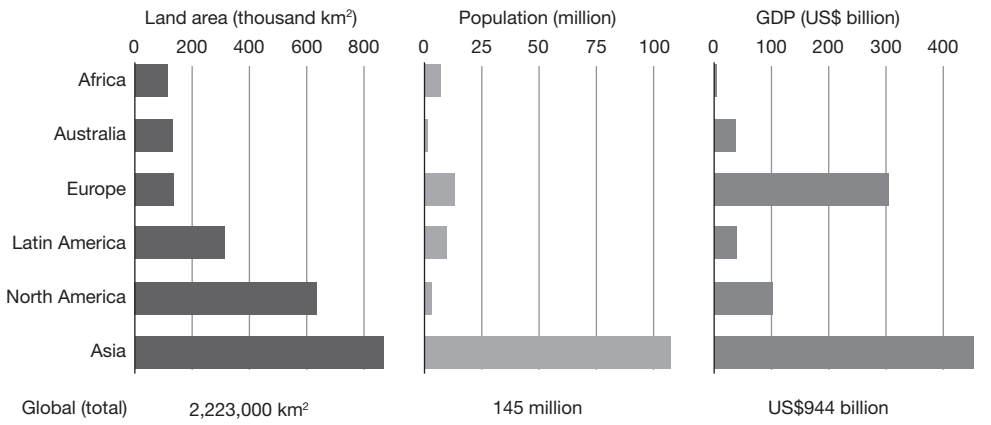


Figure 21.4 Population, area and economy directly affected by a one-metre rise in sea level
Source: USAID (2010).

build a single large power plant) and a net operating profit of $2.1 million per year, the EPC has little revenue to draw from to address these types of damage. In Fiji, unexpected shortfalls in water have forced the country's hydroelectric dams to operate below full capacity, increasing reliance on diesel imports and precipitating increases in electricity tariffs (Fiji Electricity Authority 2012).

One wide-ranging survey of climate impacts in Asia-Pacific from the United States Agency for International Development (USAID 2010) puts the 'Asian' extent of these risks into perspective. That study predicted, among other things:

- Accelerated river bank erosion, saltwater intrusion, crop losses, and floods in Bangladesh that will displace at least 8 million people and destroy up to 5 million hectares of crops.
- More frequent and intense droughts in Sri Lanka, crippling tea yields and reducing national foreign exchange and lowering incomes for low-wage workers.
- Higher seal levels inundating *half* of the agricultural lands on the Mekong Delta, causing food insecurity throughout Cambodia, Laos, and Vietnam.
- Increased ocean flooding and storm surges inundating 130,000 hectares of farmland in the Philippines affecting the livelihoods of 2 million people.
- Intensified floods in Thailand placing more than 5 million people at risk and causing $39 billion to $1.1 trillion in economic damages by 2050.

Indeed, that study concluded that Asia-Pacific will be subject to more land degraded, people displaced, prosperity threatened, and economies disrupted from sea level rises than any other part of the planet, as Figure 21.4 illustrates. Already, Asia-Pacific was home to 85 percent of deaths and 38 percent of global economic losses due to natural disasters from 1980 to 2009 (UNESCAP 2012).

Lessening vulnerability through adaptation

Community-based adaptation measures offer perhaps the best tool for enabling Asian countries to minimize the impending impacts of climate change. The term 'adaptation' describes

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adjustments in natural or human systems in response to the impacts of climate change (Ayers & Forsyth 2009). The Intergovernmental Panel on Climate Change (2007) defines 'adaptive capacity' as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. Adaptation is 'community-based' when implemented by local stakeholders, and it is sometimes called 'anticipatory adaptation' when it tries to preempt particular risks (Boyle & Dowlatabadi 2011). Most adaptation efforts are targeted towards enhancing 'resilience,' the amount of disturbance a local system, climatic or social, can absorb and still remain within the same state (Folke 2006). Table 21.2 illustrates three of the most salient types of resilience.

Adaptation efforts are necessary if communities are to respond to drastic changes in climate once tipping points, such as acidification of the ocean, alteration of the Gulf Stream, or thawing permafrost are crossed, and adaptation can also have a high relevance regarding slow or gradual changes in climate (Jerneck & Olsson 2008). Furthermore, adaptation efforts tend to be 'win–win situations,' for they not only improve resilience to climate change but often spill over into ancillary benefits such as economic stability, improved environmental quality, community investment, and local employment (Economics of Climate Adaptation Working Group 2009).

But what types of adaptation project best reduce vulnerability? To provide a partial answer, consider ongoing and diverse projects in five extremely vulnerable Asian countries: Bangladesh, Bhutan, Cambodia, the Maldives, and Vanuatu. These five countries are arguably the 'most at risk' to climate change due not only to their geographic and geophysical traits (such as lying in a floodplain, such as Bangladesh, or being incredibly flat, such as the Maldives), but also due to their economic and political traits. The United Nations (2005) classifies all five of these countries as having 'least developed country' status, meaning they have high rates of poverty, poor social indicators related to education and health, and economic vulnerability. In 2010, for instance, each of these countries had average per capita incomes, when adjusted for purchasing power parity, of *less* than $1,000 per year.[1]

In Bangladesh, the Ministry of Environment and Forests is aiming to reduce the vulnerability of coastal communities to the impacts of climate change by sponsoring afforestation in four *upazilas* (translated as sub-districts) in the coastal districts of Barguna and Patuakhali (Western region), Chittagong (Eastern region), Bhola (Central region) and Noakhali (Central region). Project managers selected sites on the basis of their expected vulnerability and also through public participation. The project has four primary components. The first is implementing interventions that generate income and couple afforestation with community livelihood. The second is enhancing national, sub-national, and local capacities of government authorities and sectoral planners so that they better comprehend climate risk dynamics in coastal areas and implement

Table 21.2 Dimensions of resilience and adaptive capacity

Type of resilience	*Explanation*
Infrastructural	Refers to the assets, infrastructure, technologies, or 'hardware' in place to ensure the delivery of services that could be disrupted by climate change (such as electricity or water)
Institutional	Refers to the endurance of an institution or set of institutions, usually government ministries or departments, in charge of planning and community and infrastructural assets
Community	Refers to the cohesion of communities and the livelihoods of the people who compose them

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appropriate risk reduction measures. The third is reviewing and revising coastal management practices and policies. The fourth is developing a functional system for the collection, distribution and internalization of climate change related data (Sovacool 2013).

In Bhutan, the government launched a project to tackle disaster risks that arise from glacial lake outburst floods (GLOFs). It has three primary components. A component focused on lowering of lake water levels is being undertaken by the Department of Geology and Mines (DGM) to reduce the risk of GLOFs at two glacial sites in the Himalayas. So far mitigation work by DGM has focused only on one lake, Thorthormi, where it is aiming to reduce the lower lake's water level by five meters, enough to eliminate hydrostatic pressure on its unstable moraine dam. An early warning component is being led by the Department of Energy, and a third community awareness component is attempting to increase the knowledge of climate change among community leaders and rural policymakers (Sovacool 2013).

Planners in Cambodia, by contrast, are focusing on building adaptive capacity for water management and agriculture. They are enhancing the ability of local government and communities to integrate long-term climate risks into policy and decision making related to subsistence farming and rice paddy production. Many of the communities living in the targeted districts in Preah Vihear and Kratie practice subsistence farming and are reliant on agriculture for their livelihoods. Adaptation efforts are focusing on educating these farmers and local leaders about climate change, and also strengthening infrastructure such as irrigation channels and ponds (Sovacool 2013).

The Maldivian government is integrating climate change risk management into formal planning processes. It is funding demonstration projects on four islands that promote a suite of different infrastructural improvements including beach nourishment, coral reef propagation, land reclamation, and community relocation. The project is also creating 'composite risk reduction plans' to be integrated with coastal protection and adaptation measures. Disaster risk profiles are being created for the four demonstration islands, revised and updated as scientific knowledge about climate change and sea level rise accumulates. These are to be synthesized into a national level 'multi-hazard early warning system' (Sovacool 2013).

The Republic of Vanuatu, an archipelago of 83 islands in the South Pacific, offers a particularly vivid final example of locally driven adaptation projects. Efforts include developing and implementing land use guidelines that consider natural hazards and climate risks, establishing early warning systems to cope with flooding, rainwater harvesting, and saltwater desalinization. Three smaller pilot project sites have been initiated on Pele Island, South Efate, and South Santo prioritizing the introduction of climate-resistant strains of crops, adapting livestock to more extreme weather, and promoting community land-use plans so farmers can share resources and arable farming sites. Projects have also emphasized the sharing of information among subsistence farmers about low tillage and soil stabilization methods, and how to reduce coastal erosion (Richmond & Sovacool 2012).

Taken as a whole, this suite of five adaptation projects is catalyzing three sets of distinct benefits: the improvement of national infrastructure, the enhancement of institutional capacity, and the betterment of community assets.

Each of the five projects enhances physical and infrastructural resilience in some way. Bangladesh's coastal forest today is almost a monoculture of mangroves. These monoculture forests have a limited ability to mitigate the impacts of climate change as they have been prone to pest outbreaks, deforestation, and logging. Historically, Bangladesh had a 500-meter buffer of mangroves to reduce the shocks of incoming storms and monsoons that has now been reduced to 12 to 50 meters in most locations. Stem borer attacks, a pest, have felled thousands of hectares and illegal deforestation and logging have worsened the situation. The project in Bangladesh

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addresses this problem and sponsors 6,000 hectares of community-based mangrove plantations, 500 hectares of non-mangrove mount plantations, about 220 hectares of dykes, and more than 1,000 kilometers of embankments. The Bangladesh project also develops early warning information and disaster preparedness systems in vulnerable areas to protect at least twenty villages and towns.

In Bhutan, planners are improving early warning systems and draining glacial lakes. Previously, the Bhutanese Department of Energy managed only a single station in Thanza, which housed two people with a wireless radio set, a single satellite phone that monitored glacial lake water levels, and (in all likelihood) copious amounts of coffee. The problem is that the two people did not always report for work, have fallen asleep, and could have been killed by the GLOF itself. Under the project, the government will replace the manual system with an automatic one composed of gauges monitoring glacial lake bathymetry (depth) as well as sensors along rivers connected to automated sirens. The project will also eventually expand the automated warning system to cover more glacial lakes.

In Cambodia, infrastructural resilience will be improved by the construction and rehabilitation of retention ponds, canals, dykes, and reservoirs that due to years of neglect are currently in disrepair. Instead of repairing these irrigation systems using design parameters derived from historical hydrological patterns, the project aims to integrate climate forecasts into their rehabilitation so that the infrastructure can withstand future climatic events such as droughts or floods.

In the Maldives, planners have moved away from exclusively building capital-intensive sea walls and tetrapods – a four legged concrete structure that breaks the impact of waves – to bolster infrastructural adaptation by replenishing natural sea ridges, planting mangroves and vegetation on shorelines, and raising the height of water storage tanks so they are no longer susceptible to sea swells and saltwater intrusion. The government has started propagating new coral reefs around Thulusdhoo and Kudhahuvadhoo and adopting beach nourishment activities to mitigate flooding.

In Vanuatu, on Epi Island investments are being made to repair roads, bridges, and wharves at risk to sea level rise, and also to erect coastal walls to reduce the severity of storm surges.

Adaptation efforts prioritize not only infrastructure but also improving institutions and propagating standards of good governance. In Bangladesh, the government provides free training sessions for local level administrators in disaster management and also facilitates input from civil society and community members in the formulation of state and national policies and regulations. In Bhutan, training of government planners is intended to build institutional capacity. The project has sponsored the training of geologists and employment for civil engineering work, and funded the creation of community-based disaster management committees, whose job it is to highlight hazards and form district disaster management teams at village levels. In Cambodia, their project is encouraging community development plans based on long-term climate forecasts and scenarios, budgeting for water resources investments that are appropriate given anticipated risks. In addition to devolving ministerial functions to local levels where possible, the project has shifted responsibility for planning onto community groups. In the Maldives, institutional capacity is being strengthened through the training of government officials in risk analysis, hazard mitigation, and land use planning. By 2014 the goal is to train at least 12 senior decision makers and planners from national ministries in Malé as well as all senior decision makers in four provinces and atolls. Part of this component involves participating with local island leaders to share knowledge and learn about local efforts. In Vanuatu, the government is sponsoring consultations with stakeholders to learn about options to bolster sector-level resilience measures which attempt to improve adaptive capacity in the agriculture, tourism, marine resources, water resources and forestry sectors.

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Finally, each adaptation project enhances community and social resilience. In many parts of the coastal forests of Bangladesh, the average annual per capita income is less than $130, one-third the national average, rendering people completely dependent on wetlands and coastal forests to meet their subsistence needs (Matthew 2007). To counter this incentive to damage forests for their survival, the LDCF project is disbursing revenues to vulnerable coastal communities so that they can diversify income sources and occupational training. One especially innovative dimension of this component is its focus on the 'Triple F' model of 'forest, fish, and food.' The coastal communities most vulnerable to rising sea levels – the places where mangroves need to be planted and forests replenished – are also those where farming and forestry are the primary sources of income. The 'FFF' model attempts to maintain community livelihood and adapt to climate change at the same time by integrating aquaculture and food production within reforested and afforested plantations.

In Bhutan, a community awareness subcomponent is being implemented in Punakha, Wangdi and Bumthang. Officials are creating a zoning map to mark several safe evacuation areas and extremely unsafe areas, and setting up emergency operation centers at district administration offices to enable them to better handle crises. Communities are being trained in their response to calamities and emergency situations using mobile phones and radio broadcasts in addition to traditional sounding gongs and bells from monasteries. These efforts will give communities a better understanding of the risks and hazards surrounding GLOF occurrences. This information also enables communities to better plan for where to locate infrastructure, homes, and farmland.

In Cambodia, in addition to devolving ministerial functions related to adaptation efforts to local levels where possible, millions of dollars of funds have been transferred to fund the agricultural adaptation projects selected by village planning committees. Training and educational sessions have also been offered to communes expressing an interest in learning about climate change.

In the Maldives, planners are attempting to increase awareness of climate change in the outer atolls. One Maldivian official told the author that the project will 'help decentralized adaptation investment planning so that each island decides what to spend its own budget on, therefore creating incentive for islands to "pick best value for the money" so that they have resources left to improve community welfare in other ways.' The program will also send 'training teams' to remote islands to 'create awareness among the community so that they can take stock of existing vulnerabilities and soft adaptation measures.'

In Vanuatu, a 'standard climate kit' with key messages about climate change has been designed and distributed to communities around Port Vila and is being scaled up for distribution in rural areas, where it will be given to tribal chiefs.

Conclusions and implications

What can we take away from both Asia's vulnerability to climate change and the adaptation efforts that some of its countries are pursuing? This section of the chapter presents five key takeaway conclusions.

First, due to the developing nature of most of its economies, population density along its coastlines, scope and extent of biodiversity hotspots, and other factors, Asia-Pacific may very well be the region of the world most at risk to the future impacts of climate change. Economists expect Asian countries to lose a larger proportion of their GDP addressing climate change. Small island developing states like the Maldives and Vanuatu may not even exist by the end of this century if sea levels rise as expected, and species extinctions could occur throughout the tropical rainforests of Indonesia and Malaysia (including Borneo) and throughout the

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region's network of coral reefs. Even large countries such as China and India are likely to suffer from climate refugees, accelerated disease epidemics, and declining food security. These issues remind us that no country throughout the region will be immune to the consequences of a changing climate, even those that have contributed few greenhouse gas emissions to the global atmosphere.

Second, adaptation efforts in the least developed countries of Asia highlight the necessity of viewing resilience to climate change as multidimensional. As Table 21.3 summarizes, Bangladesh is not only sponsoring dykes and mangrove plantations, it is incentivizing agriculture and aquaculture to improve community income and training local officials. Bhutan is not only altering the physical shape of glacial lakes and rivers, building shelters, and creating an early warning system, but educating public and private leaders about emergency preparedness and climate risks. Cambodia is not only experimenting with crops and rehabilitating canals and ponds, but educating provincial officials and empowering local villagers to decide on infrastructure investments. Maldivian planners are not only thickening coastal vegetation and nourishing coral reefs, but decentralizing planning and disbursing funds directly to local communities so that they can decide what is best for them. Vanuatu planners are hardening coastal infrastructure, soliciting feedback from stakeholders and civil society, and enhancing the informational awareness of indigenous peoples in rural areas. Their efforts remind us that adaptation may work best not by improving technology alone, but by seamlessly strengthening three types of adaptation – infrastructural, organizational, and social – to bolster ecosystems, communities, and human organizations.

Table 21.3 Efforts in least developed Asian countries and their contributions to adaptation

Country	*Infrastructural adaptation*	*Organizational adaptation*	*Social adaptation*
Bangladesh	Mangrove plantations, mound plantations, dykes, and embankments; early warning system	Capacity building through training courses for local government officials in forestry and organizational change through setting up new functional departments	Coupling of forestry programs to income generation through forest products, fish and food
Bhutan	Lowering glacial lake levels; deepening river channels; early warning system; climate shelters	Workshops for government officials at the nodal level	Community training in search and rescue, evacuations and first aid
Cambodia	Climate proofing of canals and communal ponds; experimentation with crop variation and diversity	Education sessions for provincial and local officials	Local empowerment over prioritization of climate-proofing schemes
Maldives	Sea walls; replenishment of sea ridges; mangrove afforestation; beach nourishment; coral reef propagation; repositioning of water tanks	Decentralization of adaptation planning and management to local political units	Community control over adaptation investments
Vanuatu	Roads; bridges; port infrastructure; sea walls	Consultation of adaptation options with community stakeholder	Dissemination of information kits to tribal leaders

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Such a finding has been confirmed by a few recent studies. A research team from the World Resources Institute (McGray et al. 2009) investigated 135 case studies of adaptation efforts in developing countries, and noted that a combination of three types of adaptive effort were most useful:

- Building responsive capacity, such as improving communication between institutions, or enhancing the mapping or weather monitoring capability of a government institution.
- Managing climate risks, such as disaster planning, researching drought resistant crops, or climate proofing infrastructure.
- Confronting climate change, such as relocating communities or repositioning infrastructure in response to flooding or glacial melting.

Similarly, the World Resources Institute, in collaboration with United Nations Development Programme, United Nations Environment Programme, and World Bank (2008), argued that three dimensions to resilience exist and must be promoted synergistically. Ecological resilience refers to the disturbance an ecosystem can absorb without changing into a different structure or state. Disturbances can be natural, like a storm, or human induced, such as deforestation. Social resilience refers to the ability of a society to face internal or external crises and still cohere as a community and possess a sense of identity and common purpose. Economic resilience refers to the ability for an economy to recover from shocks, and often entails having a diversified economic base composed of members with a variety of different skills.

However, multidimensional resilience also entails risks; degradation or destruction along one dimension of resilience can affect the others – the influence can be both positive and negative. Depleting a forest, for instance, could reduce ecological resilience that in turn creates fewer jobs (affecting economic resilience) and erodes the community's social resilience (by causing a high proportion of migration or dissention within the community). Conversely, improved ecological resilience can improve rents and revenue from logging (economic resilience) and also improve business skills and connection with markets (social resilience). Resilience can be reactive, making the present system resistant to change, or proactive, creating one that is capable of adapting to change (Klein et al. 2003). The key challenge for future adaptation efforts will be promoting different types of resilience – infrastructural, institutional, community – that do not tradeoff with each other, where improving one type is not to the detriment of the others

Third, this chapter demonstrates the value of a functions-based approach to resilience and adaptive capacity rather than an asset-based one. Community or social assets – things like higher wages or better technology – are useless if communities do not have the skills or capacity to use them. Knowledge and assets must be coupled with capacity and improved governance. This creates a more fluid and messy picture of adaptation, but also one that is more realistic. Assets remain only potential until communities leverage them, and adaptation programs must find ways to improve living standards.

Fourth, some types of adaptation project and knowledge are community specific whereas others transcend community types. For example, in building rainwater harvesting facilities, coastal walls, or water desalination plants, it can be difficult to transfer technology between communities within the separated islands of the Maldives and Vanuatu, or the dense rural areas of Cambodia, or the rugged mountainous areas of Bhutan, because these are fixed assets and some, like coastal walls, apply only to coastal communities. Knowledge about climate change, crop varieties, livestock, soil, and community land use, however, can travel by word of mouth and are applicable to virtually every community in each country.

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Fifth, although a less certain conclusion than the first four (it needs more research to confirm it), some of the experiences in Bhutan, Cambodia, and Vanuatu imply that smaller scale projects that involve communities in risk assessment, evaluation of adaptation options, project implementation and project appraisal have a greater likelihood of being accepted, and effective. This way, individuals are better suited to understand their vulnerabilities to climate change and see adaptation projects as legitimate. They are more democratic than large-scale projects chosen somewhat arbitrarily by consultants and ministers. And given stronger local support for new facilities and equipment, they are more likely to be maintained over the long term as adaptation measures are seen as a community asset.

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Note

1 Although the Maldives 'graduated' from its least developed country status in 2011.