# Accounting for Health Impacts of Climate Change

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# Acronyms

| | | |
|---|---|---|
| ADB | – | Asian Development Bank |
| CVM | – | Contingent Valuation Methodology |
| DMC | – | developing member country |
| IPCC | – | Intergovernmental Panel on Climate Change |
| GCM | – | global climate model or general circulation model |
| WHO | – | World Health Organization |
| UNFCCC | – | United Nations Framework Convention on Climate Change |

# Executive Summary

Asia and the Pacific host the greatest number of people vulnerable to the projected adverse impacts of climate change. Climate change is expected to modify and often to magnify the current burden of diseases in the region. With projected increases in temperature and changes in rainfall patterns (generally yielding drier climate in dry seasons and wetter climate in wet seasons), and an increase in the frequency and/or intensity of tropical cyclones and storms, climate change will significantly challenge the public health community at the global, national, and local levels.

While all populations are vulnerable to climate-induced health risks, the most vulnerable remain those in low-income groups with little adaptive capacity, among which the elderly, children, and women are most vulnerable. Reducing vulnerabilities and increasing resilience to help people cope with health effects of climate change will increasingly become a priority for the region, while new innovative approaches should be explored to protect these populations. This study aims to improve the understanding of the human health dimensions of climate change and how projects in sectors other than health, such as agriculture, water financing, and disaster risk reduction need to account explicitly for the health impacts of their interventions.

## The Threat to Health Posed by Climate Change

The Intergovernmental Panel on Climate Change (IPCC) concluded in 2007 that climate change and global warming is without doubt happening, and that in all likelihood (greater than 90% probability) this warming is primarily caused by human activity. Furthermore, recent observations show that some climate indicators are near or beyond the upper range of the IPCC's 1990 projections. A warmer and unstable climate is expected to adversely affect health, with disproportionately larger impacts on the poor and vulnerable, mainly through four courses: (i) extreme weather events causing injuries and deaths, water contamination, infectious diseases, food shortages, and mental health problems; (ii) droughts and heavy rainfall causing significant reduction in crop yield and subsistence agriculture, which may lead to malnutrition, micronutrient deficiencies, or, in more extreme cases, starvation; (iii) an increase in the number of very hot days in large cities, along with forest fires and dust storms adversely impacting air quality over broad areas (both urban and rural) and exacerbating the occurrence and intensity of associated with high temperatures (e.g., heat strokes) and respiratory diseases (e.g., asthma attacks); and (iv) changes in temperature and rainfall patterns impacting not only the occurrence of vector-borne diseases such as malaria and dengue, but also changing and possibly extending the geographical habitat of the vectors of such diseases.

East Asia, the Pacific, and South Asia are expected to bear a significant share of the impacts associated with these events. Indeed, historically, more people in Asia and the Pacific have been affected by floods, droughts, and storms than in any other region of the world: 83% of all people affected by droughts, 97% of all people affected by flood, and 92% of all people affected by storms over the period 1960–2007 resided in East Asia, the Pacific, and South Asia. The poor and the vulnerable are expected to experience the bulk of the projected impacts of climate change, including those impacts on health.

A study by the World Bank recently estimated an average global cost of adaptation in the health sector for the prevention and treatment of diarrhea and malaria alone over the period 2010–2050 to reach $1.3 billion to $1.6 billion per year (in 2005 dollars) over the period 2010–2050 (above and beyond the prevention and treatment of these diseases in a scenario without climate change). East Asia, the Pacific, and South Asia are projected to account for approximately 50% of this estimated cost of adaptation (approximately

$200 million per year in East Asia and the Pacific, and $500 million per year in South Asia). A recent study by the United Nations Framework Convention on Climate Change (UNFCCC) estimated an adaptation cost in the health sector ranging between $2 billion and $14 billion over the period 2010–2030.

If climate change is the biggest global health threat of the 21st century (Chan 2009), existing knowledge on the relationship between climate change and health, and how the nature of this relationship may change with the socioeconomic characteristics of populations, is mostly anecdotal and remains insufficient to guide policy making. Furthermore, the failure to fully and explicitly account for the health impacts of investment projects, including adaptation and mitigation investment projects, may exacerbate the health impacts of climate change, lead to underinvestment in climate change adaptation and mitigation, or elicit the wrong ranking and selection of options.

## Health Benefits of Adaptation in the Agriculture Sector, Water-financing Programs, and Disaster Risk Reduction

In addition to raising awareness about the projected impacts of climate change on health among policy makers and the civil society of the developing member countries (DMCs) of the Asian Development Bank (ADB), this study presents a framework showing the relationship between climate change and health issues in agriculture, water projects, and disaster risk reduction projects. This framework recognizes that climate change will affect all sectors, and most importantly, integrates climate-related health risk into adaptation strategies. As an integrated framework of assessing impacts, this framework can be used to provide guidance to decision makers to deal with climate change impacts and could serve as basis for climate change adaptation policy for each sector. It also explains how investments in climate change adaptation in agriculture, water financing, and disaster risk reduction generate health benefits in the affected population, apart from the direct benefits that will be realized. As a result, the framework provides the mechanisms that show how health benefits of climate change adaptation strategies in these sectors become important determinants of investment decision.

Unless DMCs systematically anticipate, plan, and prepare adequate and cost-effective responses to the health effects of climate change at geographic and sector levels, on short-term and long-term bases, the health impacts and costs of climate change are likely to overwhelm the capacity of the public sector to offer appropriate health care services in times of need. As such, the Commission on Climate Change and Development and the World Health Organization clearly point out that the health sector needs to be involved in strategic planning in sectors such as agriculture, water financing, and disaster management. This includes ensuring the integration of health concerns into national adaptation programs of action. The analysis presented in this study shows that accounting for the health impacts of climate change demands better use of existing information and systems, and new accessible tools and frameworks to help the decision-making process. The study also suggests ways to identify and quantify impacts of climate change, and how to monetize those impacts into costs and benefits in water, agriculture, and disaster risk reduction.

The countries involved in the study (Nepal, the Philippines, and Tajikistan) are currently building climate resilient health sectors, by strengthening health systems and ensuring adequate water and sanitation for the population. Nepal and the Philippines have identified the health sector as a priority sector within their national adaptation plans, though in a manner that does not yet fully recognize and account for the role of adaptation options in agriculture, water, and disaster risk reduction to reduce the incidence of climate-induced health impacts. This process has just commenced, providing both country and regional opportunities for governments and their development partners.

This study contributes to the development of a methodological approach aimed at ensuring that the health impacts of projected climate change be accounted for not only by the health sector itself, but by sectors through which these impacts may emerge, in particular agriculture, water, and disaster risk reduction.

## Three Key Messages

The study yields the following three key messages.

First, while planning adaptation investments in the health sector must be a significant component of an overall climate change adaptation strategy, to a large extent it remains an approach based on reacting to an increase in the health impacts of climate change as opposed to preventing such increases. Sectors in which prevention can take place include agriculture, water financing, and disaster risk management. A climate change adaptation strategy that focuses on preventing the projected health impacts of climate change is likely to be more effective (in terms of both impacts and costs) than a strategy focused on reacting.

Second, and as a corollary to the above message, the health benefits of adaptation investments in agriculture, water, and disaster risk reduction should be explicitly accounted for in the design and economic analysis of such investments. Lacking such explicit consideration, the nature and extent of these adaptation investments are likely to be inappropriate (under-investment in adaptation and/or selection of inadequate adaptation options), and will result in health impacts and costs that could otherwise be limited or avoided. There is a fundamental need to better understand the nature of the health impacts of climate change as well as of the health impacts of investment projects, including adaptation projects in agriculture, water, and disaster risk reduction. Incorporating measures that produce health benefits in climate change sector development can provide strong justification for supporting climate change action and investments.

Third, climate experts, health experts, and economists need to better communicate with each other to ensure that information produced by one group of experts is of use to other groups. In this way, it is possible to provide investment projects and programs that are better integrated and that present a development case that decision makers can understand and support.

The study does not aim to comprehensively address all health issues raised by climate change, nor does it attempt to provide comprehensive answers to issues cited above. Its greatest benefits may be to stimulate awareness about the projected impacts of climate change on health among policy makers, climate change experts, and economists in DMCs, and thereby address significant gaps in our existing knowledge.

# Introduction

In early 2007, the Intergovernmental Panel on Climate Change (IPCC) released its *Fourth Assessment Report*, in which it noted that over the past 150 years, global average surface temperature has increased by 0.76°C, and that most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic (human) greenhouse gas concentrations.[1] It is generally believed that this global warming has caused changes in precipitation patterns, increased the frequency and/or intensity of extreme weather events, and has caused a rise in mean global sea levels.

Looking into the future, the IPCC (2007) concluded:

- Even if greenhouse gas concentrations were to be stabilized at existing levels, anthropogenic warming and sea-level rise will continue for centuries to come, due to the timescales associated with climate processes and feedback effects;
- Both past and future anthropogenic carbon dioxide emissions will continue to contribute to warming and sea-level rise for more than a millennium;
- World temperatures may rise by between 1.1°C and 6.4°C during the 21st century, depending on which emissions scenario is realized ("best estimates" range between 1.8°C and 4°C);
- Sea levels will rise by 18 centimeters (cm) to 59 cm by 2100 mostly as a result of thermal expansion of the oceans, and only partly as a result of a global reduction in snow cover;
- There is a greater than 90% confidence level that there will be more frequent warm spells, heat waves, and heavy rainfall; and
- There is a greater than 66% confidence level that there will be an increase in droughts, tropical cyclones, extreme high tides, and storm surges.

Asia and the Pacific host the greatest number of people at risk of adverse impacts of climate change. Historically, more people in Asia and Pacific have been affected by floods, droughts, and storms than in any other region of the world: 83% of all people affected by droughts, 97% of all people affected by flood, and 92% of all people affected by storms over the period 1960–2007 resided in East Asia, the Pacific, and South Asia (Laplante 2010).

With projected increases in temperature, changes in rainfall patterns, and increase in the frequency and/or intensity of tropical cyclones and storms, climate change is expected to impact almost every sector of human and economic activity, every region of the world, and every community, including the public health community.[2]

Although climate change is the biggest global health threat of the 21st century (Chan 2009), the status of knowledge on the relationship between climate change and health, and how the nature of this relationship may change with the socioeconomic characteristics of any given country, is mostly anecdotal, and remains insufficient to guide policy making. Furthermore, the failure to fully and explicitly account for the health impacts of investment projects, including adaptation investment projects, may exacerbate the health impacts of climate change, lead to under-investment in climate change adaptation, or elicit the wrong ranking and selection of adaptation options.

Unless developing member countries (DMCs) of the Asian Development Bank (ADB) systematically anticipate, plan, and prepare adequate and cost-effective responses to the health effects of climate change, the

1 IPCC (2007). In the language of the IPCC, "very likely" stands for "with a probability greater than 90%."

2 Thousands more have cases of suspected malaria. Furthermore, more than 200 health facilities have been damaged or destroyed, greatly reducing the available health care for millions of survivors.

health impacts and costs of climate change are likely to overwhelm the capacity of the public sector to offer even basic health care services in times of needs. The Commission on Climate Change and Development and the World Health Organization (WHO) have stated that the health sector needs to be involved in strategic planning in sectors such as agriculture, water, and disaster management. This includes ensuring the integration of health concerns into national adaptation programs of action. ADB has developed an operational plan and WHO has adopted a regional framework that explicitly recognizes the importance of addressing the health impacts of climate change. The documents point out the need to account for the potential health impacts of adaptation investments in other key sectors such as transport, energy, agriculture, urban development, and water financing.

The analysis presented in this study shows that accounting for the health impacts of climate change demands better use of existing information and systems and new, accessible tools and frameworks to help the decision-making process. In particular, given the existing practice of subjecting investment projects to an analysis of their economic and financial costs and benefits, it is here argued that explicitly accounting for the health impacts of investment projects in sectors such as agriculture and water, as well as in projects aimed at mitigating natural disasters, implies including these health impacts within the framework of the cost–benefit analysis of these projects. Without explicit inclusion, adaptation investments in these sectors and programs will underestimate the true economic benefits of projects, which may lead to a project being unduly rejected, or the wrong option (in the context of a cost-effectiveness analysis) being selected. In both cases, the health impacts of climate change will be larger than they would otherwise have been, had the project not been rejected or the correct option been selected.

Section III discusses briefly the relationship between health and climate change. Section IV presents an approach to account for the health benefits of adaptation investments in water and agriculture, as well as for mitigation of natural disasters. Conclusions are offered in Section V.

# Climate Change, Health, and Costs

## Climate Change and Health

In May 2009, Costello et al. (2009) called climate change "the biggest global health threat of the 21st century." It further noted that the "epidemiological outcome of climate change on disease patterns worldwide will be profound, especially in developing countries, where existing vulnerabilities to poor health remain." It is projected that several negative health impacts will be exacerbated as a result of climate change in Asia and the Pacific. While the nature of the relationship remains uncertain, climate change is likely to affect health through a number of different pathways, as shown in Table 1.

A first, and perhaps most immediate, pathway through which climate change may affect health is water. Adequate and clean water resources are vulnerable to climate change stress, and the lack of these heightens the risk of diarrhea and cholera in rural and urban areas. Greater rainfall, combined with warmer temperatures, is likely to make provision of clean water and adequate sanitation more complex and costly, and expand the vectors for waterborne communicable diseases, including malaria and dengue fever. For example, by 2080, approximately 6 billion people may be at risk of contracting dengue fever as a consequence of climate change, 2.5 billion more than if climate were to remain unchanged (Hales et al. 2002). In Indonesia (Figure 1) and the Philippines (Figures 2 and 3), there is a clear correlation between the incidence of dengue fever and La Niña's years (Indonesia) and rainfall (the Philippines). Recent data from Kathmandu, Nepal also show the number of typhoid cases at their highest annual levels, with peaks in maximum and minimum temperatures (Figure 4), as well as in rainfall (Figure 5).

A second pathway, independent of water-related issues, is temperature increases. The urban population in developing countries is rapidly increasing, and is often combined with poor housing and living conditions. These conditions increase the risk of heat strokes due to the heat island effect.[3]

A third pathway is agriculture, as the agricultural productivity of existing crops is expected to be challenged significantly. Agriculture is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops, while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative. In turn, this may have adverse impacts on nutrition and food security. Climate change is expected to boost the number of malnourished children by 2050. More specifically, in East Asia, instead of 2.3 million malnourished children in 2050—which is projected in the case of no change in the climate—this number is projected to reach between 4.9 million to 5.3 million with climate change. In South Asia, instead of 52.3 million malnourished children in 2050 under prevailing climate conditions, predictions indicate that between 57.2 million and 58.2 million will be malnourished due to climate change (ADB 2009a). In a recent report, it was estimate that calorie availability in 2050 may not only be lower than in the no-climate-change scenario, but that it may actually decline relative to 2000 levels throughout the developing world (IFPRI 2009).

Finally, a fourth pathway is extreme weather events and heat waves (e.g., droughts, storms, rainfalls), which are expected to become more severe and/or more frequent. Over the period 1960–2007, the number of people around the world affected by droughts, floods, storms, and extreme temperatures has increased

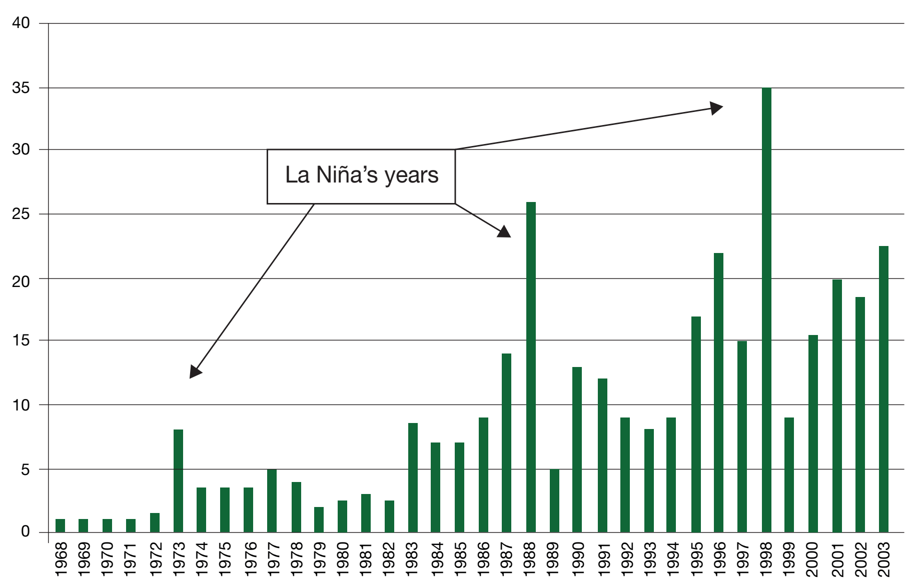
[3] The *heat island effect* is a phenomenon that has accompanied, and increased with, urbanization. It refers to the fact that human-made structures tend to attract and retain heat at a higher rate than is normal in nature.

## Table 1 Projected Health Impacts of Climate Change

| Health Outcome | Effects of Climate Change |
|---|---|
| Cardiovascular and respiratory diseases | • Heat waves cause short-term increases in mortality.<br>• Deaths from heat stroke increase during heat waves.<br>• Weather affects concentrations of harmful air pollutants. |
| Allergic rhinitis | • Weather affects the distribution, seasonality, and production of aeroallergens. |
| Deaths and injuries, infectious diseases, and mental disorders | • Floods, landslides, and windstorms cause death and injuries.<br>• Flooding disrupts water supply and sanitation systems and may damage transport systems and health care infrastructure.<br>• Floods may provide breeding sites for mosquito vectors.<br>• Floods may increase post-traumatic stress disorders. |
| Starvation, malnutrition, and diarrheal and respiratory diseases | • Drought reduces water availability for hygiene.<br>• Drought increases the risk of forest fires, which adversely affects air quality.<br>• Climate change may decrease food supplies (crop yields and fish stocks) or access to food supplies. |
| Mosquito-, tick-, and rodent-borne diseases | • Higher temperatures shorten the development time of pathogens in vectors and increase the potential of transmission to humans.<br>• Each vector species has specific climate conditions (temperature and humidity) to be sufficiently abundant to maintain transmission. |
| Waterborne and food-borne diseases | • Survival of disease-causing organisms is related to temperature.<br>• Climate conditions affect water availability and quality.<br>• Extreme rainfall can affect the transport of disease-causing organisms into the water supply. |

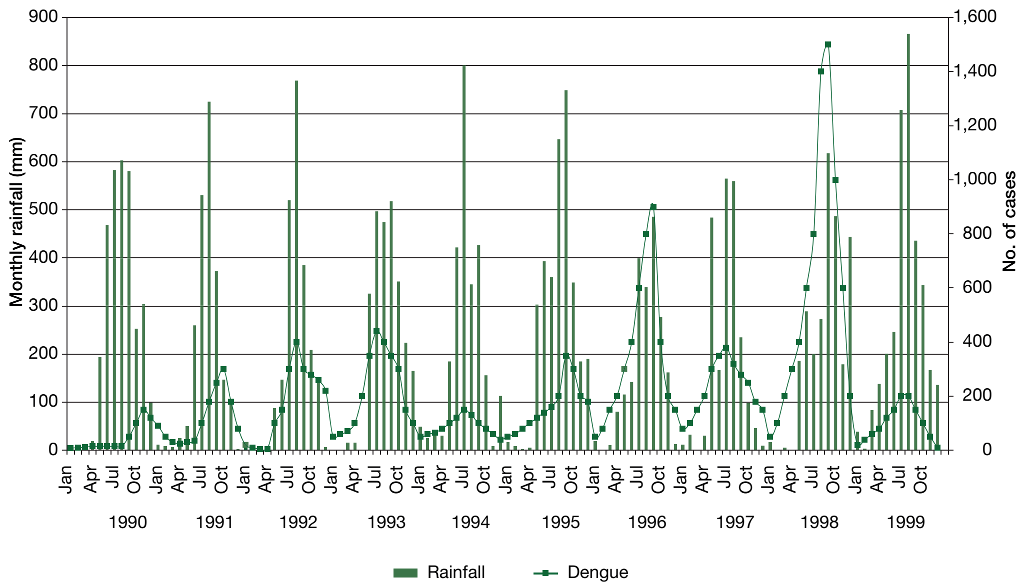
Source: Adapted from Kovats, K., L., Ebi, and B. Menne. 2003. *Methods of Assessing Human Health Vulnerability and Public Health Adaptation to Climate Change.* Geneva: World Health Organization. www.who.dk/document/E81923.pdf

## Figure 1 Incidence of Dengue Fever in Indonesia (per 100,000 people)




Source: Asian Development Bank. 2009. *The Economics of Climate Change in South East Asia: A Regional Review*. Manila.

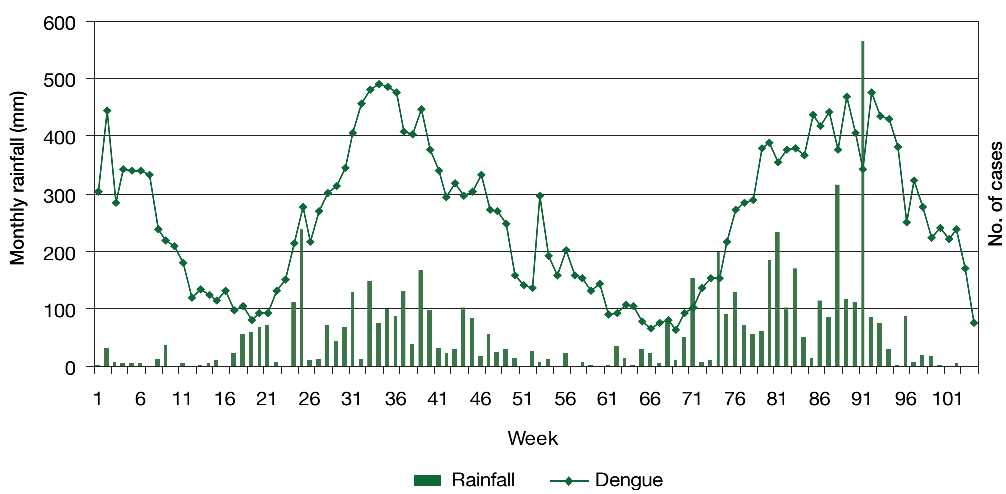
Figure 2 Monthly Rainfall and Number of Cases of Dengue Fever in the Philippines, 1990–1999




Apr = April, Jan = January, Jul = July, mm = millimeter, no. = number, Oct = October.

Sources: Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and Department of Health, Philippines.

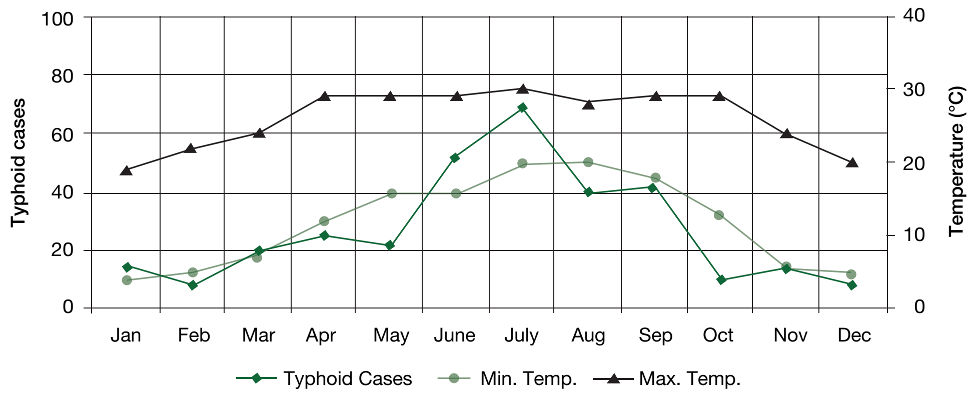
Figure 3 Monthly Rainfall and Number of Cases of Dengue Fever in the Philippines, 2008–2009




mm = millimeter, no. = number.

Sources: Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and Department of Health, Philippines.

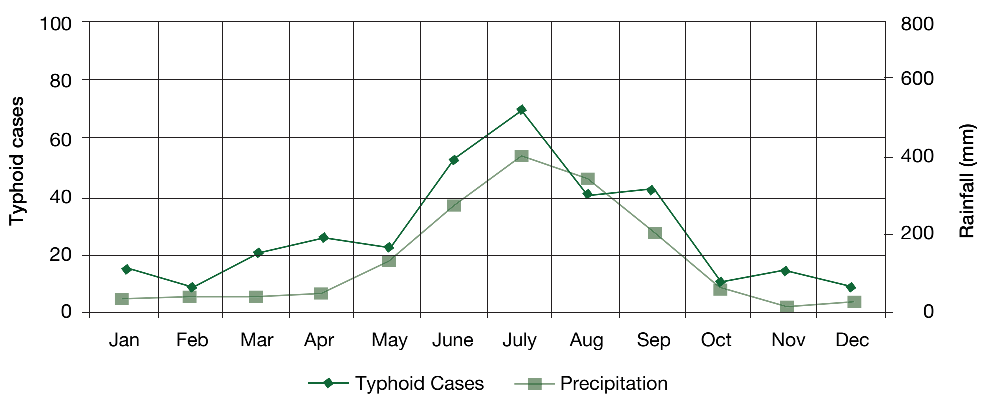
## Figure 4 Typhoid Cases and Temperatures in Kathmandu Valley, 2006




Jan = January, Feb = February, Mar = March, Apr = April, Aug = August, Sep = September, Oct = October, Nov = November, Dec = December, °C = degree Celsius, Min. Temp. = minimum temperature; Max. Temp. = maximum temperature.

Source: Patan Hospital records.

## Figure 5 Typhoid Cases and Rainfall in Kathmandu Valley, 2006




Jan = January, Feb = February, Mar = March, Apr = April, Aug = August, Sept = September, Oct = October, Nov = November, Dec = December, °C = degree Celsius, mm = millimeter.

Source: Patan Hospital records.

approximately tenfold (Table 2).[4] Over this 48-year period, more people in Asia and the Pacific have been affected by floods, droughts, and storms than in any other region of the world: 83% of all people affected by droughts, 97% of all people affected by flood, and 92% of all people affected by storms over the period 1960—2007 resided in East Asia, the Pacific, and South Asia. Figure 6 shows a wealth of extreme weather events in Tajikistan solely over a brief period in 2005.

[4] The increase in the number of affected people cannot be accounted for solely by an increase in population. Over the same period, the world population approximately doubled, from 3.2 billion to 6.5 billion.

Table 2 Number of People Affected by Extreme Weather Events, 1960–2007

| | 1960–1969 | 1970–1979 | 1980–1989 | 1990–1999 | 2000–2007 |
|---|---|---|---|---|---|
| Drought | 117,899,704 | 263,706,885 | 592,746,376 | 309,913,523 | 631,553,213 |
| Flood | 42,374,639 | 207,877,106 | 468,400,647 | 1,436,005,223 | 845,939,199 |
| Storm | 30,244,783 | 52,539,673 | 141,405,617 | 224,336,097 | 333,244,475 |
| Extreme temperature | – | 600 | 40,202 | 7,134,684 | 5,376,889 |
| **Total** | **190,519,126** | **524,124,264** | **1,202,592,842** | **1,977,389,527** | **1,816,113,776** |

– = no data available.

Note: Estimates based on the International Emergency Events Database (EM-DAT) maintained by the Centre for Research on the Epidemiology of Disasters (CRED). The database covers 210 countries.

Source: Laplante, B. 2010. Poverty, Climate Change, and the Economic Recession. In Bauer, A., and M. Thant, eds. *Poverty and Sustainable Development in Asia: Impacts and Responses to the Global Economic Crisis*. Manila: Asian Development Bank.

Climate change threatens to reverse the gains made toward achieving the Millennium Development Goals. In particular, climate change threatens to worsen poverty and burden marginalized and vulnerable groups with additional hardships. In Southeast Asia, many poor people live in coastal areas and low-lying deltas, which are expected to experience the brunt of the impacts related to sea-level rise and the intensification of storm surges (Dasgupta et al. 2011). Anecdotal and empirical evidence strongly support the hypothesis that the lower a household's level of income is, the greater the likelihood of it being adversely impacted by natural hazards.[5]

Several factors explain the nature of this relationship. First, the livelihoods of poor people are known to be significantly dependent on natural resources. When disasters disrupt the flow of goods and services provided by these resources, and more generally by ecosystems, the poor find themselves in a precarious situation. When disasters destroy capital (e.g., machines or cattle) the poor typically lack access to financial resources to restore capital to its pre-disaster level. Second, increases in income enable individuals and households to respond to increased risk (including risk associated with disasters) by employing additional precautionary measures.[6] Third, the poor are often located in areas that are more susceptible to high variability in temperature and rainfall, such as hilly and steep slopes and flood plains.[7] Fourth, richer societies are more resilient as a result of the positive correlation between income and education, financial development, and greater institutional capacity. Finally, poor households and communities often have limited access to adequate information to make informed decisions pertaining to climate change and its projected impacts, as well as limited influence on policy making processes. These considerations may partly explain why Tajikistan ranks very low in terms of adaptive capacity, while being most vulnerable to climate change (Figure 7).

## Health Costs of Climate Change

Estimating the future costs of the health impacts of climate change is a daunting task, fraught with uncertainty and incomplete information. This task is made even more difficult when analyzing specific subsets of defined populations, such as those living in poverty.

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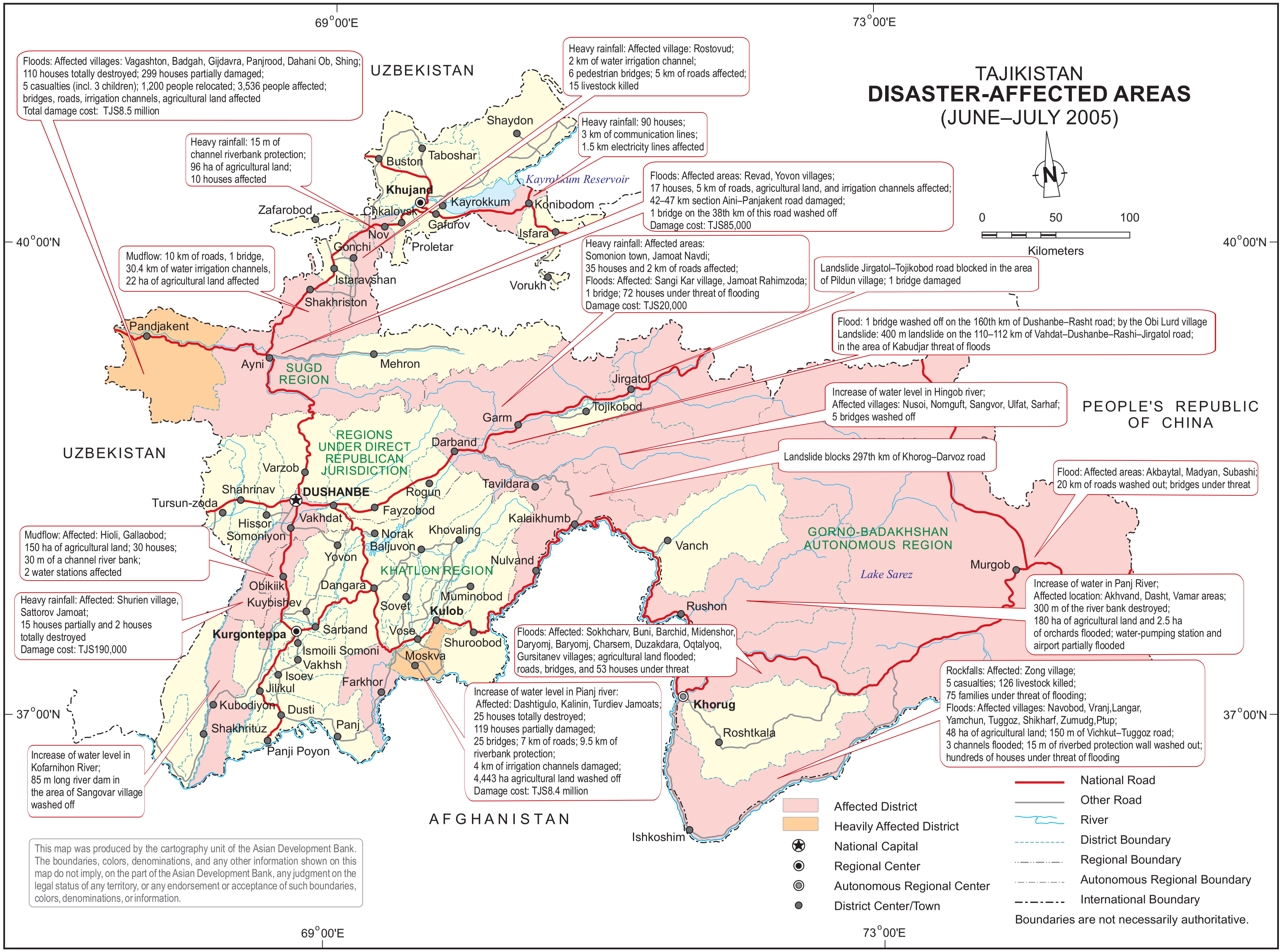
5 See Laplante (2010) for a review of the empirical evidence.

6 Both the demand for security and the private capacity to invest in security (through better access to financial capital and private savings) increase as income increases.

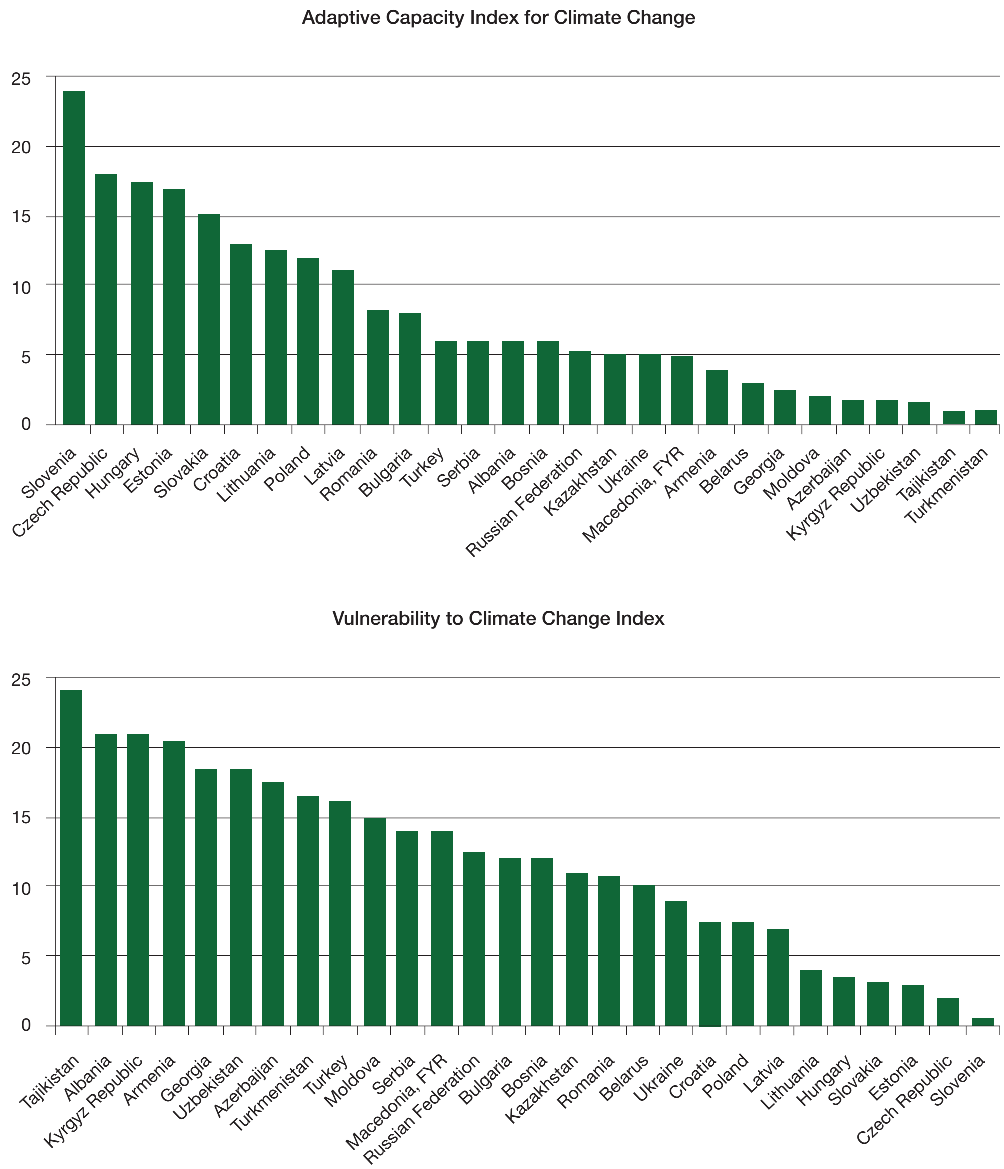
7 "Ninety percent of the disaster victims worldwide live in developing countries where poverty and population pressures force growing numbers of poor people to live in harm's way on flood plains, in earthquake prone zones, and on unstable hills. The vulnerability of those living in risk-prone areas is perhaps the single most important cause of disaster casualties and damage."— Secretary General of the United Nations Kofi Annan, 1999.

Figure 6 Natural Hazards in Tajikistan




ha = hectare, incl. = including, km = kilometer, m = meter, TJS = somoni.

## Figure 7 Tajikistan's Adaptive Capacity and Vulnerability to Climate Change[a]




FYR = former Yugoslav Republic.

[a] The adaptive capacity index is estimated by combining social measures (income inequality), economic measures (GDP per capita) and institutional measures. The lower the value of the index, the lower the estimated adaptive capacity. The vulnerability index is a composite index that combines estimates of exposure to climate change, sensitivity to climate change, and adaptive capacity. The higher the value of the index, the greater the estimated vulnerability.

Source: World Bank. 2009. *Adapting to Climate Change in Europe and Central Asia*. Washington, DC.

Using the Policy Analysis for the Greenhouse Effect Integrated Assessment Model, Stern (2006) estimates the total cost of a business-as-usual climate change scenario over a period of 200 years. This cost includes the "market impacts" of climate change (impacts on goods and services for which market prices can be used to monetize the impacts into costs), as well as the "non-market impacts" of climate change, which in the *Stern Review* include impacts on environment and human health. Based solely on market impacts, the study estimates the total cost of business-as-usual climate change to equate an average reduction in global per capita consumption of 5%, now and forever. Once the impacts on the environment and human health (non-market impacts) are included, the total cost of business-as-usual increases from the estimated 5% to 11% (Table 3). In the case of a high climate scenario, the estimated total cost of business-as-usual increases from 6.9% to 14.4%, once non-market impacts are included.

While the *Stern Review* includes "non-market" impacts, the report notes these are difficult to monetize and that the results from this monetization process are problematic in terms of concept, ethical framework, and practicalities. Perhaps more importantly for the purpose of this paper, it is to be noted that the *Stern Review* systematically refers to the "environment and human health" impacts of climate change, and not solely to the impacts on human health. As pointed out by Confalonieri et al. (2007), studies focusing on the welfare costs of climate change impacts (such as the *Stern Review*) rarely include health outcomes explicitly, and if they do, the studies are generally limited to assessing the costs of extreme heat- and cold-related mortality and malaria.

A limited number of studies have strictly focused their effort on estimating the health costs of climate change. The UNFCCC report estimated the global adaptation costs for the health sector to be in the range of $4 billion–$12 billion per year in 2030 (UNFCCC 2007). The adaptation costs are for preventing the additional climate change–induced cases of *solely* diarrheal disease, malnutrition, and malaria in 2030 (Table 4). Note that malnutrition accounts for a very small proportion of the estimated total costs, while

### Table 3 Estimated Losses in Current per Capita Consumption[a]

| Climate scenario | Economic | Mean | 5th percentile | 95th percentile |
|---|---|---|---|---|
| Baseline climate[b] | Market impacts | 2.1 | 0.3 | 5.9 |
| | Market impacts + risk of catastrophe | 5.0 | 0.6 | 12.3 |
| | Market impacts + risk of catastrophe + non-market impacts | 10.9 | 2.2 | 27.4 |
| High climate[b] | Market impacts | 2.5 | 0.3 | 7.5 |
| | Market impacts + risk of catastrophe | 6.9 | 0.9 | 16.5 |
| | Market impacts + risk of catastrophe + non-market impacts | 14.4 | 2.7 | 32.6 |

[a] The numbers in the table represent the estimated reduction (in percentage terms) in per capita consumption, relative to the business-as-usual scenario.

[b] The two climate scenarios (baseline climate and high climate) are Policy Analysis for the Greenhouse Effect climate scenarios. The baseline climate scenario produces a mean warming of 3.9°C by 2100 (relative to pre-industrial level) and a 90% confidence interval of 2.4°C–5.8°C. The high climate scenario introduces the impacts of feedback effects increasing temperature changes to higher levels. It produces a 90% confidence interval increases to 2.6°C–6.5°C.

Source: Stern, N. 2006. *The Economics of Climate Change: The Stern Review*. Cambridge, UK: Cambridge University Press.

### Table 4 Projected Costs to Manage Additional Climate Change–Related Cases of Diarrheal Diseases, Malnutrition, and Malaria in 2030 ($ million)

| Emissions Scenario[a] | Diarrheal Diseases | | Malnutrition[b] | | Malaria[b] | |
|---|---|---|---|---|---|---|
| | **Middle** | **High** | **Middle** | **High** | **Middle** | **High** |
| S550 | 1,706 | 6,024 | 63 | 131 | 1,859 | 3,876 |
| S750 | 1,983 | 6,814 | 95 | 189 | 2,310 | 4,784 |
| UE | 2,731 | 9,010 | 72 | 146 | 3,664 | 7,537 |

[a] S550 = stabilization of emissions at 550 parts per million (ppm) carbon dioxide ($CO_2$) equivalent, S750 = stabilization of emissions at 750 ppm $CO_2$ equivalent, UE = unmitigated emissions.

[b] Middle point of the provided cost estimates presented in Ebi, K.L. 2008. Adaptation Costs for Climate-Change Related Cases of Diarrheal Disease, Malnutrition, and Malaria in 2030. *Global Health*.

malaria and diarrheal diseases contribute to approximately the same proportion to this total cost (though for the high-cost scenario, diarrheal diseases account for a slightly higher share).

As noted by Ebi (2008), a key assumption behind these estimates is that the number of annual cases of diarrheal diseases, malaria, and malnutrition, as well as the cost of treatment, remain constant over the period of analysis. Given the projected increase in population, this implies that the rates of incidence of each of these health outcomes decrease over time in line with the rate of population growth. Ebi (2008) notes:

> Conducting a sensitivity analysis that incorporated these population increases would require assumptions of future incidence rates of these health outcomes, based on assumptions of socioeconomic development, including improvements in health care delivery, the rate of deployment of current interventions, and the development of more effective technologies. Using the current number of cases in the analysis in effect assumes that incidence will decrease as population increases, without attribution of the possible reasons for such a decline (page 6).

In a recent World Bank study (2010) such attribution was explicitly modeled insofar as income is concerned. The study used WHO econometric models using panel data on income and health to project cause-specific deaths and disability-adjusted life-year rates by demographic group through 2030 (WHO 2004). Accounting solely for this attribution (as income increases, the rate of incidence falls), the average global costs of adaptation in the health sector for the prevention and treatment of diarrhea and malaria alone (not including malnutrition) over the period 2010–2050 was estimated to reach $1.3 billion (in the dry weather scenario) to $1.6 billion per year (in the wet weather scenario), in 2005 dollars (Table5). East Asia, the Pacific, and South Asia account for half of this estimated cost of adaptation.

As a result of the different modeling approaches, these estimates (World Bank 2010) are significantly lower than those reported by Ebi (2008). One concludes that (i) there remains large uncertainty as to the adaptation costs for climate change–related health outcomes, and (ii) the analyses have so far captured a limited number of climate change–related health outcomes. For example, neither Ebi (2008) nor the

## Table 5 Average Annual Adaptation Cost for Human Health: Preventing and Treating Malaria and Diarrhea, by Region and Decade, 2010–2050 ($ billion at 2005 prices, no discounting)

| Period | EAP | ECA | LAC | MENA | SA | SSA | All |
|---|---|---|---|---|---|---|---|
| **Wet scenario** | | | | | | | |
| 2010–2019 | 0.7 | 0.1 | 0.0 | 0.1 | 1.0 | 0.9 | 2.8 |
| 2020–2029 | 0.2 | 0.0 | 0.0 | 0.1 | 0.7 | 0.7 | 1.7 |
| 2030–2039 | 0.1 | 0.0 | 0.0 | 0.1 | 0.3 | 0.7 | 1.2 |
| 2040–2049 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.8 | 1.0 |
| 2010–2049 | 0.2 | 0.0 | 0.0 | 0.1 | 0.5 | 0.8 | 1.6 |
| **Dry scenario** | | | | | | | |
| 2010–2019 | 0.5 | 0.0 | 0.0 | 0.1 | 0.8 | 0.6 | 2.0 |
| 2020–2029 | 0.1 | 0.0 | 0.0 | 0.1 | 0.7 | 0.6 | 1.5 |
| 2030–2039 | 0.1 | 0.0 | 0.0 | 0.0 | 0.3 | 0.6 | 1.0 |
| 2040–2049 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.6 | 0.7 |
| 2010–2049 | 0.2 | 0.0 | 0.0 | 0.0 | 0.5 | 0.6 | 1.3 |

EAP = East Asia and Pacific, ECA = Europe and Central Asia, LAC = Latin America and Caribbean, MENA = Middle East and North Africa, SA = South Asia, SSA = Sub-Saharan Africa.

Note: Numbers have been rounded to the first decimal point. “0.0” billion should not be read as absolute zero.

Source: World Bank. 2010. *The Economics of Adaptation to Climate Change: Synthesis Report*. Washington, DC.

World Bank (2010) studies include cost estimates for other infectious diseases that are known to be climate sensitive (such as dengue), heat and cold stresses, population displacement, and increased air pollution.

## Health in Sector Project Investments

Perhaps more importantly, the World Bank (2010) explicitly recognizes that the estimated adaptation costs in the health sector would be considerably higher if adaptation investments in the water infrastructure sector (some of which are related to mitigating adverse health outcomes associated with the provision of poor water supply and sanitation services), agriculture (some of which are related to mitigating malnutrition), and natural disasters (some of which have important health outcomes) were to fail to deliver intended benefits. Similarly, Ebi (2008) and Kovats (2009) also recognize that adaptation in other sectors is probably more important for reducing the health impacts of climate change (through disaster mitigation, food and water security, and providing decent infrastructure) than adaptation in the health sector itself.

ADB's *Strategy 2020* (2008b) describes ADB's role in health:

> ADB recognizes that health is vital to development, productivity, social inclusion, and gender equity. ADB will contribute to improvements in health mainly through infrastructure projects, such as water financing programs, and through governance work that focuses on public expenditure management for cost-effective delivery of health programs and services to all population groups.

ADB seeks to promote health improvements in DMCs through investment in infrastructure projects.

WHO makes explicit reference to the needs of addressing health concerns in sectors other than the health sector per se. Through its Regional Committee for Western Pacific, WHO developed a Regional Framework for Action to Protect Human Health from the Effects of Climate Change in the Asia–Pacific Region. In a resolution adopted in 2008, member states are urged to

(i) develop national strategies and plans to incorporate current and projected climate change risks into health policies, plans, and programs to control climate-sensitive health risks and outcomes;
(ii) strengthen existing health infrastructure and human resources, as well as surveillance, early warning, and communication and response systems for climate-sensitive risks and diseases;
(iii) establish programs to reduce greenhouse gas emissions by the health sector;
(iv) assess the health implications of the decisions made on climate change by other sectors, such as urban planning, transport, energy supply, food production and water resources, and advocate for decisions that provide opportunities for improving health;
(v) facilitate the health sector to actively participate in the preparation of national communications and national adaptation programs of action; and
(vi) actively participate in the preparation of a work plan for scaling up WHO's technical support to member states for assessing and addressing the implications of climate change for health.

However, experience to date indicates that the health impacts of infrastructure investment projects and climate change adaptation projects are rarely explicitly accounted for. Even in projects where health impacts (either positive or negative) are mentioned or referred to, most assessment of these health impacts remain of a qualitative nature. In most instances, there is no attempt to explicit quantify and monetize the health impacts of the projects (Box 1 presents typical examples of this approach). These impacts remain peripheral to the assessment of the costs and benefits of projects, including projects aimed at adaptation or climate-proofing. These health impacts, not being explicitly quantified, monetized, and included in such analysis, will therefore not play any decisive role in the decision-making process pertaining to the acceptance or rejection of projects, or the selection of a specific option when many options are feasible.

At a national level, the Government of Nepal recognizes the health impacts of climate change as a key threat to the people of Nepal and as such, is the topic of one of the six multi-stakeholder Thematic Working Groups (TWGs) supporting Nepal's National Adaptation Programme of Action (NAPA). However, none of the other TWGs (such as "agriculture and food security" and "water and energy") are explicitly required to account for the potential health impacts of their sector interventions on health, and none are explicitly required to include the possible health benefits of adaptation investments in their respective sector (Box 2).

### Box 1 Health Impacts in Asian Development Bank Project Cost–Benefit Analysis

Excerpts from: Suzhou Creek Rehabilitation Project (People's Republic of China) Report and Recommendation to the President (PRC 32121); May 1999

"Suzhou Creek is a water source for irrigation and industrial processing, and receives large discharges of untreated agricultural, industrial, and municipal wastewater and solid waste. As a result, Suzhou Creek has become severely polluted with high concentrations of biochemical oxygen demand and chemical oxygen demand. The direct beneficiaries will be the 3 million people living in the project area who will have improved living conditions and public health standards (…).

Important benefits not valued in the economic analysis include (…) health benefits."

Excerpts from: Karnataka Urban Development and Coastal Environmental Management Project (India) Report and Recommendation to the President (IND 29120); November 1999

"The project will support the Government's priority investment in the urban sector, based on an urban sector development strategy that focuses on improving the welfare of the urban poor and the devolution of municipal management responsibility from states to cities. The Project will significantly improve the health and welfare of the urban poor who currently suffer from inadequate and unsafe water supplies and sanitation conditions.

Health benefits, due to cleaner living environments (…) were not valued."

Excerpts from: Water Supply and Sanitation Investment Program (Azerbaijan) Report and Recommendation to the President (AZE 42408); September 2009

"Following the dissolution of the Soviet Union, the quality and efficiency of water service delivery declined in Azerbaijan, due to poor management and inadequate investments. The existing [water supply and sanitation] WSS system is over 50 years old. Water supply sources are in a poor state of repair, and other modes of supply (e.g., through private vendors) are expensive and/or unreliable. Water treatment facilities in secondary and small towns are either absent or largely dysfunctional. Poor sanitation and leaking sewers create serious health risks and environmental hazards. The Investment Program will improve public health and environment in areas having about 500,000 residents total.

Some key benefits that do not lend to quantitative analysis due to lack of information include (…) health impacts."

Excerpts from: Metropolitan Sanitation Management and Health Project (Indonesia) Report and Recommendation to the President (INO 39071); June 2010

"Many urban and peri-urban areas in Indonesia have priority disease profiles linked to water supply and sanitation: diarrhea, skin disease, intestinal worms, malaria, and dengue. Poor people in urban slum areas, particularly children, women, and elderly people, are more affected than others. The impact [of the project] will be reduced environmental pollution of surface water and shallow groundwater in Medan and Yogyakarta. Reduced environmental pollution will benefit public health and improve the quality of life in these cities.

The economic benefits of the project are significant, especially in the densely populated parts of the participating cities, where population pressure is high and surface and groundwater pollution pose major public health hazards. The expected benefits consist largely of reduced mortality and morbidity, followed by the avoided cost of septic tank desludging."

Authors: These economic benefits are not quantified nor monetized in the above report.

### Box 2 Health in Nepal's National Adaptation Programme of Action Process

In 2009, the Government of Nepal adopted climate change–related policies and adaptation programs in the context of its National Adaptation Programme of Action (NAPA). The NAPA is supported by six multi-stakeholder thematic working groups (TWGs), each led by a line ministry: agriculture and food security (Ministry of Agriculture); forestry and biodiversity (Ministry of Forests and Soil Conservation); water and energy (Ministry of Energy); public health (Ministry of Health and Population); climate induced disasters (Ministry of Home Affairs); and human settlements and infrastructure (Ministry of Physical Planning and Works).

Each thematic group has been requested to submit their priority proposals (projects) to the NAPA working committee. From this list, the NAPA working committee selected immediate priority projects for funding under the Least Developed Countries Fund. The public health TWG submitted a list comprising the following priorities: (i) investigating and responding to disease outbreak emergencies in all 75 districts; (ii) reducing public health impacts of climate through evidence based research and piloting; and (iii) strengthening forecasting and early warning and surveillance systems on climate change and health in six pilot districts (Dhankuta, Doti, Kaski, Kathmandu, Makawanpur, and Surkhet).

Upon prioritizing their sector-specific list of projects, criteria used by other TWGs did not include the potential impacts on health of their recommended projects. Each TWG worked independently from one another and did not seek possible intersectoral adaptation investments.

Source: Pradhan, B. 2010. Key Sector Analysis: Health Adaptation in Nepal. Mimeo. Kathmandu.

# Managing the Health Impacts of Climate Change through Sector Projects

Within an institution such as a development bank, the use of financial and economic cost–benefit analyses is a key to assessing projects. Managing the health impacts of climate change through sector investment projects implies explicitly accounting for these impacts in the context of such analyses. This, in turn, requires that these health impacts be identified, quantified, and then monetized. This process is described in greater detail below.

## Identifying and Quantifying the Health Impacts of Climate Change

As illustrated in Figure 8, at the outset it is important to identify the nature of climate-sensitive diseases that affect the country or the local communities of interest. Similarly, it should be expected that the incidence of such diseases may also depend on variables other than climate variables (such as the socioeconomic characteristics of the local population). Data may be required on these other determinants to better isolate the nature of the relationship between climate and health. Finally, in a first step of identification, one must assess whether or not data is available to support any attempt to quantify and monetize the health impacts of climate change, where this data (if existing) is located, and how access may be granted. In circumstances where data may not be available, it may be of interest to identify whether data could be collected from the national health monitoring system or international sources.[8]

Figure 8 Pinpointing the Health Impacts of Climate Change

- What are the climate-sensitive diseases of interest in the country or local communities?
- What is the current burden of these diseases?

↓

- What factors other than climate should be considered?
- What data is available, where, and how to access the data?

↓

- Is health monitoring system sufficient to collect the required data?

Source: Author.

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[8] Health data can be found in various sources. The *World Health Report*, published by WHO, provides regional data for all major diseases (www.who.int/whr/en). WHO databases exist on water and sanitation (www.who.int/entity/water_sanitation_health/database/en), and malnutrition (www.who.int/nutgrowth/db). The United Nations Children's Fund (UNICEF) has its datasets for children's health at its website (www.unicef.org). The International Emergency Event Database (EM-DAT) provides data on disasters (www.em-dat.net). Ministries of health perform regular disease surveillance and report results to WHO annually. Government district hospitals and private hospitals also keep health statistics regularly.

### Box 3 Constraints to Identifying and Quantifying the Impacts of Climate Change in Nepal

The data and information on climatic events and health impacts in both soft and hard forms are limited, which pose the crucial problem and challenge for health planning in Nepal. If available, the data is either limited or generated for specific project purposes and therefore cover limited areas. Owing to a lack of adequate information, most of the planning and decision making is taking place on an ad-hoc basis with limited concerns to long-term outcomes. The following basic constraints with regard to climate change events and health impacts have been identified:

- There exist limited stations for recording data on weather, hydrological, and environmental phenomena. They now are available only for major urban areas. Rugged topography, remoteness, and drudgery of movements have further aggravated the problems of gathering data.
- There is a lack of solid and reliable information and analysis relating climatic events and human health. As a result, it is difficult to establish cause-and-effect relationships between them. Projecting the future impacts of climate change on health is difficult.
- Various government ministries (health, environment, water resources, home affairs, etc.) have collected data on climatic events and health, but there has been a lack of integration and coordination to link the data nature, size, quality, and methods among these bodies.

The most general constraint with all these organizations is the very limited budget allocated for establishing databases, as well as limited research activities to generate information on climate phenomena and health. Few studies on adaptation measures for weather- and climate-related disasters have been undertaken. Climate extreme indices and indicators for monitoring, regional climate modeling, glacier risk reduction, etc., do not provide adequate information for climate change adaptive measures.

Source: Pradhan, B. 2010. Key Sector Analysis: Health Adaptation in Nepal. Mimeo. Kathmandu.

Quantifying the future health impacts of climate change requires a number of different steps, each fraught with its own difficulties, uncertainty, and incomplete information. This report proposed a methodological approach, presented in Figure 9. Without being exhaustive, these steps include:

(i) **Selecting an emissions scenarios**. The Special Report on Emissions Scenarios was prepared by the IPCC for the *Third Assessment Report* (2001), on future emissions scenarios to be used for driving global circulation models to develop climate change scenarios. There exist 4 broad families of emissions scenarios (A1, A2, B1, and B2) with the A1 emissions scenario comprising 3 different subsets (A1F1, A1B, and A1T). These scenarios differ as to the assumptions pertaining to economic growth, population growth, the adoption of new technologies, and the degree of integration among nations of the world. Different emissions scenarios provide different estimates of changes in climate, and (all other things being equal) different estimates of climate changes will provide different estimates of the future incidence of health impacts. In a recent study of the potential impacts of climate change in Southeast Asia, ADB (2009a) used the A1FI and B2 emissions scenarios. In terms of greenhouse gas emissions, A1F1 represents a high emissions scenario (rapid, fossil-intensive economic growth), and B2 represents a medium-case scenario. A World Bank study (2010) uses the A2 emissions scenario. Recent empirical evidence indicates that actual greenhouse gas emissions tend to follow emissions levels projected by high emissions scenarios of the A1 family.

(ii) **Selecting a global climate model or general circulation model (GCMs)**. GCMs are computer models used to simulate the earth's climate systems. GCMs are the main tools used to project future climate changes due to the continued anthropogenic inputs of greenhouse gases. The major advantage of using GCMs as the basis for creating climate change scenarios is that they estimate changes in climate for a large number of climate variables in a physically consistent manner such as temperature, precipitation, pressure, wind, humidity, and solar radiation. However, (a) GCMs typically provide projections at a scale in the order of hundreds of square kilometers, which in

## Figure 9 Estimating the Future Burden of Diseases

**STEP 1:** Select the disease of interest (e.g., dengue, cholera, etc.)

| Estimates using historical data | Future projections |
| --- | --- |
| **STEP 2:** Select the period of time (e.g., 5 years, 20 years, etc.) | **STEP 5:** Select the period of time (e.g., 20 years, 50 years, etc.) |
| **STEP 3:** Specify the possible nature of the relationship between climate and burden of disease, controlling for the impact of all other variables. For example:<br><br>D = F(Temperature, Rainfall, Education level, Income per capita)<br>where D is the burden of diseases (no. of cases per 10,000). | **STEP 6:** Project in the future non-climate independent variables (e.g., education level, income per capita, etc.)<br><br>**STEP 7:** Estimate the burden of disease in the future *without* climate change, using the estimated relationship from STEP 4, and the value of the future non-climate independent variables from STEP 6. |
| **STEP 4:** Quantify the relationship between climate and burden of disease. | **STEP 8:** Select the emissions scenario and the global circulation models (GCMs) from which climate variables of interest will be projected. Selecting more than one emissions scenario and GCM may be of interest to provide a probable range of impacts, and not simply a point estimate.<br><br>**STEP 9:** Select climate variable of interest. This may depend on the nature of the disease of interest and its expected correlation with climate variables.<br><br>**STEP 10:** Project the values of the climate variables of interest over the selected period of time from the selected emissions scenario and GCMs.<br><br>**STEP 11:** Estimate the burden of disease in the future with climate change, using the estimated relationship from STEP 4, the value of the future non-climate independent variables from STEP 6, and the value of the future climate variables from STEP 10. |

Source: Author.

many instances would be too large to project health impacts; and (b) there are 22 GCMs with their own sets of (uncertain) projections about future climate variables. At the global level, it is generally found that the model projections by 2050 do not diverge significantly insofar as temperature increases are concerned, but do vary significantly for precipitation changes.

(iii) **Selecting a method of downscaling GCM projections**. The problem that pertains to the coarse resolution of GCMs can be overcome by downscaling.[9] Downscaling increases both spatial resolution (e.g., from hundreds to tens of kilometers) and temporal resolution (e.g., from monthly to daily). There are two main approaches for downscaling: dynamical downscaling

[9] GCMs are run at coarse spatial resolution (typically of the order 50,000 square kilometers [19,000 square miles]) and are unable to resolve important subgrid scale features such as topography. As a result, GCMs cannot be used for local impact studies. To overcome this problem, downscaling methods are developed to obtain local surface weather from regional atmospheric variables that are provided by GCMs.

(using regional climate models) and statistical downscaling (using empirical relationships). These two approaches will yield different estimates of projected changes in climate variables.[10] As a result of the above (selection of an emissions scenario, a GCM, and a downscaling approach), for each grid cell of the world (of say 50 kilometers [km] by 50 km), there can be up to 264 estimates of future climate variables (including temperature and rainfall among other variables). A possible approach to this multiplicity of estimates is to calculate the mean (average) of the projected values. This, in effect, would assume that projected values of future climate variables across all of the Special Report on Emissions Scenarios and GCMs are equally likely. A possibly undesirable outcome of such an approach is that it could result in projecting zero change in the values of climate variables relative to the baseline. An alternative approach is to attempt capturing the full range of results by selecting extreme values on either side of the projected change (e.g., if rainfall or humidity is of interest, by selecting the "wettest" and "driest" projection).[11]

(iv) **Assess and estimate the nature of the relationship between climate variables and health (for the selected diseases)**. Projecting future health impacts of climate change requires some level of understanding of the relationship that may exist between climate variables (such as temperature, rainfall, drought, and heat waves) and the health issues of concern. This may be addressed using a combination of local historical data (time series or panel dataset) and knowledge, as well as national and global data. At the global level, a popular model, the Modeling Framework for the Health Impact Assessment of Man-Induced Atmospheric Changes includes modules for vector-borne diseases, including malaria, dengue fever and schistosomiasis, thermal heat mortality, and ultraviolet-related skin cancer due to stratospheric ozone depletion. Possible outputs are (a) for vector-borne disease modules, cases, and fatalities from malaria, and incident cases for dengue fever and schistosomiasis; (b) for the thermal stress module, cardiovascular, respiratory and total mortality; and (c) for skin cancer module, malignant melanoma and non-melanoma skin cancer.

(v) **Selecting population projections**. The number of cases of different types of climate-dependent diseases will inherently depend on projections related to the number of people that may be exposed to these diseases. While this may be of relative ease at national levels (using national or global datasets), the level of uncertainty pertaining to these population projections will increase as one's interest moves to subnational levels. Focusing on a specific population, such as those living in poverty, creates challenges. For example, answering the question "What could potentially be the number of poor households in the Central Highlands of Viet Nam in 2050?" would require the use of numerous assumptions.

(vi) **Selecting projections of future socioeconomic characteristics**. The incidence (e.g., number of cases of a specific disease per 1,000 people) of climate-dependent diseases depends not only on climate variables, but also on socioeconomic characteristics, among which income and education are known determinants. This implies that estimates of the health impacts of climate change will also depend on projections for these socioeconomic characteristics. Key to the nature of these projections is the recognition that future socioeconomic characteristics will themselves be a function of climate change. Hence, projecting future values of socioeconomic characteristics (in particular, income) must be consistent with the selection of emissions scenarios (see Box 4 for an example).

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[10] For more details on the issue of downscaling, see Wilby and Wigley (1997), Wilby et al. (1998), and Wood et al. (2004).

[11] Institutions such as the Canadian Centre for Climate Research, the United Kingdom Meteorological Office, the UK Hadley Centre, and the Goddard Institute for Space Studies are continuously working to refine the predictions and making adjustments based on new data.

### Box 4 Accounting for the Role of Socioeconomic Characteristics

A simple application has recently been implemented by Dasgupta et al. (2011). The specification of the risk model incorporates three effects: economic development, weather, and education. The formal specification is as follows for (country) $i$ in period $t$:

$$(1)\quad \ln(R_{it}) = \ln\left[\frac{L_{it}}{P_{it}}\right] = \beta_0 + \beta_1 G_{it} + \beta_2 E_{it} + \beta_3 R_{it} + \beta_4 T_{it} + \varepsilon_{it}$$

where

R = Impact risk (death from floods, affected by floods, and affected by droughts)
L = Total loss (persons killed or affected)
P = Population
G = Gross domestic product (GDP) per capita
E = Educational enrollment rate
R = Precipitation
T = Temperature
$\varepsilon$ = A random error term

With such models, using projections of GDP per capita, education, as well as of precipitation and temperature (as determined by global circulation models), it is possible to estimate a range of possible future deaths from floods or number of people affected by floods or droughts. While Dasgupta et al. have used ”death from floods” as well as the number of people ”affected by floods” or “affected by droughts,” a similar analysis could be undertaken for cases of weather-related diseases and conditions such as typhoid, dengue, and malnutrition.

Source: Dasgupta, S., et al. 2011. Exposure of Developing Countries to Sea-level Rise and Storm Surges. *Climate Change*. 106(4). pp. 567–579.

## Monetizing Health Impacts in Projects

While numerous approaches may be used to monetize the health impacts of investment projects (including those of climate change adaptation projects), they all aim at measuring individuals’ willingness to pay to access a specific good or service (such as clean water). These may be grouped into two broad approaches. A first approach relies on estimating monetary outlays that individuals (or households) may undertake to prevent illness (defensive expenditure methodology) or to treat illness (cost-of-illness methodology). In the economic literature, these are known as the revealed preferences approaches to monetizing health impacts. When the cost-of-illness approach is used, foregone work compensation incurred by individuals is generally also included. A second approach relies on asking individuals to state their willingness to pay for the provision of a specific good or service. This approach, which falls under the category of stated preferences approaches, is generally known as the contingent valuation approach.

Each approach has its strengths and weaknesses. In particular, both the defensive expenditure methodology and the cost-of-illness methodology are relatively straightforward to apply. On the other hand, these two approaches do not capture other adverse impacts associated with illnesses, such as pain and suffering. In other words, the “real cost” of being sick is likely to be much higher than what defensive or treatment expenses will reveal. The contingent valuation approach will provide a better approximation of the economic costs of diseases. However, it is a time-consuming approach that requires strong economic expertise. These are discussed briefly below.[12] The steps involved in applying the two approaches are presented below.

[12] It is not the intent of this section to provide a detailed review of monetization approaches. The interested reader has access to an extensive literature on the topic, including Alberini and Krupnick (2003); Krupnick (2004); and Wilhelmine, Robinson, and Lawrence (2006).

## Defensive Expenditure Methodology

The defensive expenditure methodology assesses the cost of undertaking activities aimed at offsetting changes in environmental quality. There are three steps involved.

### Step 1

Since the expected change in environmental quality is assumed to impact people's behavior, the first step is to identify the population that may be exposed to the expected change in environmental quality.

### Step 2

Through surveys, identify the actions and activities that individuals undertake to avoid exposure to degraded environmental quality.

### Step 3

Measure the cost to individuals of undertaking these actions or activities.

The strengths of the defensive expenditure methodology are

(i) the methodology is simple to implement and require minimal degree of technical or economic expertise; and

(ii) since it is based on actual behavior undertaken by individuals, it may have more credibility during consultations with stakeholders.

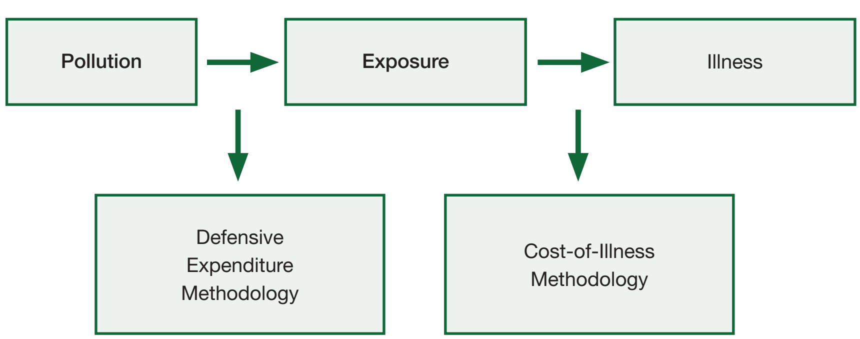
However, a key limitation of this methodology is that even if individuals are willing to pay to protect themselves against exposure to degraded environmental quality, the estimated expenditure does not provide a true measure of the benefits of the protection undertaken or of the true cost of the degraded environmental quality. In other words, costs are normally not a measure of the benefits. However, in appropriate circumstances, it may be said that the estimated expenditure provides a lower estimate of the true economic cost of the degraded environmental quality (and therefore of the benefit of the defensive activities).

## Cost-of-Illness Methodology

The cost-of-illness methodology simply relies on estimating expenditure associated with treating the illness (Figure 10).

The cost-of-illness methodology is relatively simple to implement. It simply estimates the direct and indirect costs associated with treating or experiencing a particular illness. There are essentially three steps involved.

Figure 10 Defensive Expenditure and Cost-of-Illness Methodologies




Source: Author.

## Step 1

As with the defensive expenditure methodology, since the expected change in environmental quality is assumed to impact people's behavior (that is, treating illness); an important and key step is to identify the population that may be exposed to the expected change in environmental quality. This relates to the issue of geographical and stakeholder scoping.

## Step 2

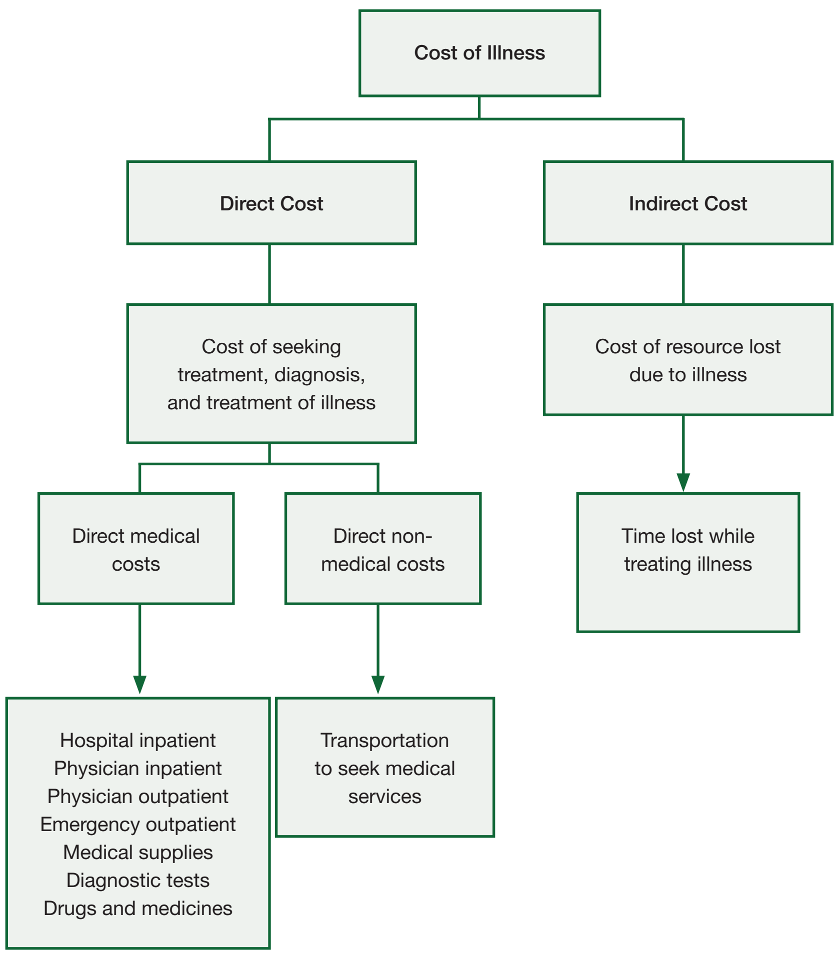
Observe (essentially by means of surveys) the actions and activities that individuals are doing to treat illnesses.

## Step 3

Measure the costs for individuals undertaking these actions of activities.

As indicated in Figure 11, it is important to recognize that the cost of illness is made of different components. First, individuals must incur a direct cost to seek treatment for illnesses. This is covered by both medical and non-medical cost. Second, there may be an indirect cost associated with the illness, due to loss of valuable productive time while treating the illness. This cost must also be included in the cost of illness.

Figure 11 Components of the Cost of Illness




Source: Author.

Table 6: Cost of Treating Diarrheal Diseases in Nepal

| Description | Year | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
| Total number of patients | 7,036,459 | 7,846,667 | 8,642,852 | 9,576,761 | 9,800,451 | 9,552,307 | 9,699,858 | 8,797,639 | 12,137,059 |
| Number of patients with diarrheal disease | 550,392 | 608,347 | 625,150 | 724,386 | 787,094 | 785,336 | 739,915 | 680,819 | 1,398,106 |
| Number of patients treated with ORS | 486,148 | 540,769 | 552,508 | 641,228 | 697,260 | 693,831 | 649,171 | 602,516 | 977,337 |
| Number of patients treated with IV fluid | 31,6900 | 29,541 | 27,543 | 27,368 | 24,431 | 22,843 | 14,285 | 10,074 | 10,573 |
| Number of patients treated with zinc and ORS[a] | – | – | – | – | – | – | – | – | 438,578 |
| Total treatment cost of zinc and ORS treatment (NRs thousand) | – | – | – | – | – | – | – | – | 23,200 |
| Total treatment cost of ORS treatment (NRs thousand) | 8,751 | 9,734 | 9,945 | 11,542 | 12,551 | 12,507 | 11,685 | 10,845 | 17,592 |
| Total treatment cost of IV fluid (NRs thousand) | 9,507 | 8,862 | 8,263 | 8,210 | 7,329 | 6,853 | 4,286 | 3,022 | 3,172 |
| Total cost of all treatments (NRs thousand) | 18,258 | 18,596 | 18,208 | 19,753 | 19,880 | 19,360 | 15,971 | 13,867 | 43,964 |

– = no data available, IV = intravenous, NRs = Nepal rupees (NRs70 = $1), ORS = oral rehydration solution.
[a] Zinc tablets were not used before 2008.

Source: Pradhan, B. 2010. Key Sector Analysis: Health Adaptation in Nepal. Mimeo. Kathmandu.

The above approaches to estimate the impacts of climate change have been used in a number of studies.[13] Accounting solely for the direct medical costs, the cost of treating diarrheal diseases in Nepal was estimated to be NRs18 (approximately $0.25) for oral rehydration solution treatment and NRs300 (approximately $4.0) for intravenous fluid treatment. Using these numbers, the total cost of treating diarrheal diseases was estimated to reach in excess of $600,000 in 2008 (Table 6).

## Contingent Valuation Methodology

Applying the contingent valuation methodology (CVM) involves surveys that ask how much people are willing to pay for specific environmental goods or services in a specific but hypothetical situation where changes are brought to the goods or services.[14] It is "contingent" because the scenarios presented to the

[13] See for example: Ebi (2008), Hubler et al. (2008), Markandya and Chiabai (2009), McMichael et al. (2003), and Van Rensburg and Blignault (2002).

[14] For more detailed information on good practices related to this methodology, see Gunatilake et al. (2007).

respondents are hypothetical. The use of hypothetical scenarios is in fact the most significant critique made of CVM. CVM is often equated with "willingness-to-pay" studies, which can, at times, give the false impression that using CVM consists of surveys with few questions related to willingness to pay. However, a serious and credible application of CVM is demanding and must follow some specific steps and protocols to produce credible results, as reviewed below.

### Step 1

Defining the hypothetical situation for consideration by the respondents is the first step. The hypothetical situation must be clearly and precisely defined; together with survey respondents and the suggested change in environmental quality.

### Step 2

The next step is to determine the type and size of the sample, ensuring that the sample is representative of the entire population and sufficient to yield statistically significant results.

### Step 3

The third step describes the approach by which the survey will be conducted (e.g., by mail, telephone, or interview).

### Step 4

The fourth step is the survey design, the most critical part of the process, entailing several sub-steps. It starts with a focus group discussion to test the wording of the survey questions and the overall methodology and approach. The focus group discussion will help developing the questionnaire, which will be pre-tested and then finalized. A key issue in survey design is the elicitation method (i.e., how precisely will the willingness-to-pay question be presented to the respondent?). There are three (3) main elicitation methods:

(i) **Open-ended.** The respondent is asked to "state" his/her highest willingness to pay (values are not suggested to the respondent).

(ii) **Close-ended.** The respondent is presented with a specific value (in local currency) and is asked whether or not (Yes or No) he/she would be willing to pay this amount (this is also referred to as a dichotomous choice).

(iii) **Payment card.** The respondent is presented with a sequence of potential payments (in local currency) and is asked to select the highest value that he/she would be willing to pay.

### Step 5

The final step is to compile and analyze the results. The data is compiled and analyzed using statistical techniques appropriate to the type of question.

CVM (or willingness-to-pay study) is a complicated, lengthy, and demanding methodology. To ensure overall quality, the sample of respondents must be selected correctly and the survey must be properly designed, pre-tested, and implemented. The survey questions must focus on specific changes in environmental goods or services and the changes (against a "no-change scenario") have to be clearly defined and understood by survey respondents. If respondents do not clearly understand what they are being asked to pay for (hypothetically), then the stated estimates will not be a reliable measure of the true willingness-to-pay.

Estimates of the economic costs of climate change on health would generally find their use in the context of a cost–benefit analysis aimed at reducing the impacts of climate change on health. The concept of cost–benefit analysis of adaptation options is described below.

## Cost–Benefit Analysis of Climate Change Adaptation Investments

The goal of the economic analysis of adaptation options is to provide decision makers with information on expected costs and benefits of each technically feasible option and to rank these options according to the net total benefit (measured in present value terms). In circumstances where all adaptation options deliver exactly the same benefits, it is sufficient to undertake a cost-effectiveness analysis where adaptation options are compared in terms of the cost of achieving the stated benefit. With respect to climate change and the assessment of adaptation options, cost–benefit analysis plays an identical role. The cost–benefit analysis of adaptation options aims to identify and quantify all impacts of the various adaptation options deemed to be technically feasible, and then to monetize these impacts into costs and benefits. In this sense, the cost–benefit analyses of adaptation options are no different than for any other investment project, and will be implemented along a similar step-wise process.[15]

Specific features of climate change pertain to the uncertainty associated with its various impacts. For example, will extreme weather events become more frequent or more severe, and if so, by how much? Or will the recurrence of flooding or droughts increase? Given the significant uncertainty associated with the predicted impacts of climate change, conducting cost–benefit analysis of adaptation options requires paying particular attention to the treatment of risk and uncertainty in the assessment of the costs and benefits of adaptation options. This process is described in more details below.

The cost–benefit analysis of adaptation options to climate change is to a large extent similar to the type of cost–benefit analysis developed in the context of natural disaster risk management.[16] As such, it is important to recognize the task of the economist to monetize the impacts of climate change and the adaptation options as these have been identified and quantified by other experts (engineers, hydrologists, health experts, etc.). This issue will be discussed further below in the section on cost–benefit analysis of adaptation.

(i) A key feature of the approach is to recognize that costs and benefits of the adaptation options must be assessed by identifying and quantifying the impacts of climate change under two scenarios:

- **Scenario 1**: What would be the expected health impacts of climate change if there were to be no adaptation measures in place?
- **Scenario 2**: What would be the expected health impacts of climate change if there were to be adaptation measures in place?

Once these two scenarios are described, the benefit of the adaptation options is assessed together with the quantified and monetized impacts "with vs. without" the adaptation options in place.

(ii) The cost–benefit analysis and the alternative adaptation options should account for the following important factor. First, to recognize that climate change hazards and vulnerabilities may change over the time of an investment project. Hence, the assessment of the adaptation benefits may be different if they are based on an assumption of existing population, ignoring that future population may be different throughout the lifetime of the project. These changes in vulnerability need to be explicitly accounted for in the assessment of the costs and/or benefits of some or all adaptation options. This issue is discussed in detail below.

[15] See Boardman et al. (2005) for a description of the step-wise process.

[16] See for example Mechler (2005).

## Cost–Benefit Analysis of Adaptation: Accounting for Risk and Uncertainty

Conducting any cost–benefit analysis implies looking into the future and asking how the "universe" of interest may look without the project, and with the project (the impacts of the project being the difference between these two scenarios). The exercise (looking into the future) is lacking complete information, and fraught with risk and uncertainty. This is true of all cost–benefit analyses, whether they be related to climate change or not. To this extent, the risk and/or uncertainty associated with projected climate change impacts is no different, and the analytical tools available to account for risk and uncertainty in the conduct of a project cost–benefit analysis are of relevance in the context of assessing the costs and benefits of climate change adaptation options. While climate change brings a new source of uncertainty, methodological tools exist to handle such uncertainty in the context of cost–benefit analysis.

Two approaches may be applied to explicitly account for risk and uncertainty within the framework of the cost–benefit analysis. Each is briefly discussed below.[17]

## Approach 1: Sensitivity Analysis

The technique most widely applied to account for risk and uncertainty is sensitivity analysis (or sensitivity testing). In the context of conducting the cost–benefit analysis of an adaptation option, this type of analysis essentially involves changing the value of one or more variables which affect the adaptation option's costs or benefits (for example, assuming that the cost of the adaptation option could be 20% higher than estimated; or assuming that the storm return period could be 1 in 30 years instead of the estimated 1 in 50 years), and for each such changes to re-compute the net present value of the option. This exercise may be repeated as much as may be deemed necessary.

Switching values are often computed in the context of sensitivity testing. Switching value is the value of a specific variable that makes the net present value switch from positive to negative, or conversely.

The purpose of such sensitivity testing is to raise the level of confidence in the outcome of the analysis. A key advantage of sensitivity testing is the simplicity, though it has severe limitations, including:

(i) Sensitivity testing is highly subjective, due to the fact that no specific reason justifies the direction (smaller or larger) or the extent by which the value of a specific variable may be assumed to change;

(ii) More importantly, sensitivity testing does not take into account the probability that the value of any specific variable may differ from the value originally estimated. As a result of this serious limitation, while sensitivity analysis allows for computing a range of net present values, within which the actual net present value of the adaptation option may fall, it does not allow for computing the expected net present value of the adaptation option.

This last shortcoming explains the second approach used to account for risk and uncertainty in the cost–benefit analysis.

## Approach 2: Probabilistic Analysis

Conducting a "probabilistic cost–benefit analysis" involves attaching a probability distribution for the possible value of any given specific cost or benefit component of the project, instead of attaching a single deterministic value. Such probability distributions may be constructed using records of historical data.

Probabilistic analysis allows selecting multiple variables that can all be varied simultaneously according to the specific probability distribution attached to each variable. This process, known as a Monte Carlo simulation analysis, requires that a specific value of each individual variable (cost component or benefit component) be generated randomly according to the specific probability distribution attached to each

[17] For more details, see for example ADB (2002) and Rayner et al. (2002).

variable. For any given draw of specific values, the net present value of the adaptation option is calculated. This computerized process is then repeated a large number (many thousands) of times.

The outcome of the analysis is a probability distribution of net present values. This probability distribution allows the computation of an "expected" net present value of the adaptation option under consideration instead of solely a given net present value, or a range of net present values. The same probability distribution also allows one to estimate the probability that the net present value of the adaptation option be negative.

The conduct of probabilistic analysis is demanding if performed manually. However, packaged software allows the conduct of Monte Carlo simulation analysis in a relatively simple way. It is important to note that the conduct of risk (or probabilistic) cost–benefit analysis is an important recommendation already applied by ADB since 2002 to supplement the simplistic use of sensitivity analysis.

### Decision Rule

It should not be presumed that adaptation (climate proofing) should be pursued wherever technically feasible. From an economic point of view, climate proofing may not be the best course of action in a number of specific circumstances. The outcome of the economic analysis of adaptation options, summarized as the net present value of these options, will guide the nature of the recommendations.

The decision rule guiding the selection of adaptations is similar to the decision rule for any investment project:

If only one *technically* feasible adaptation option exists, then the decision rule is:

| | |
|---|---|
| If Expected Net Present Value > 0 | Recommend implementing the adaptation option |
| If Expected Net Present Value < 0 | Recommend rejecting the adaptation option (do nothing) |

If more than one technically feasible adaptation option exists, then the decision rule is to select the adaptation option with the largest expected net present value. If all adaptation options were to yield a negative expected net present value, then the best option is to do nothing.

### Prioritize and Select Adaptation Option(s)

In circumstances when more than one adaptation option is technically feasible, the analysis should result in a prioritized list of adaptation options for implementation, which are selected from among several possibilities. Their prioritization can be based on an assessment of their technical feasibility, as well as their benefits and costs, social acceptability, and the opportunities they may offer for synergies with national priorities. While the use and outcome of a cost–benefit analysis may be given more weight in the prioritization process, it is important to recognize that other factors and criteria's may also influence decision making.

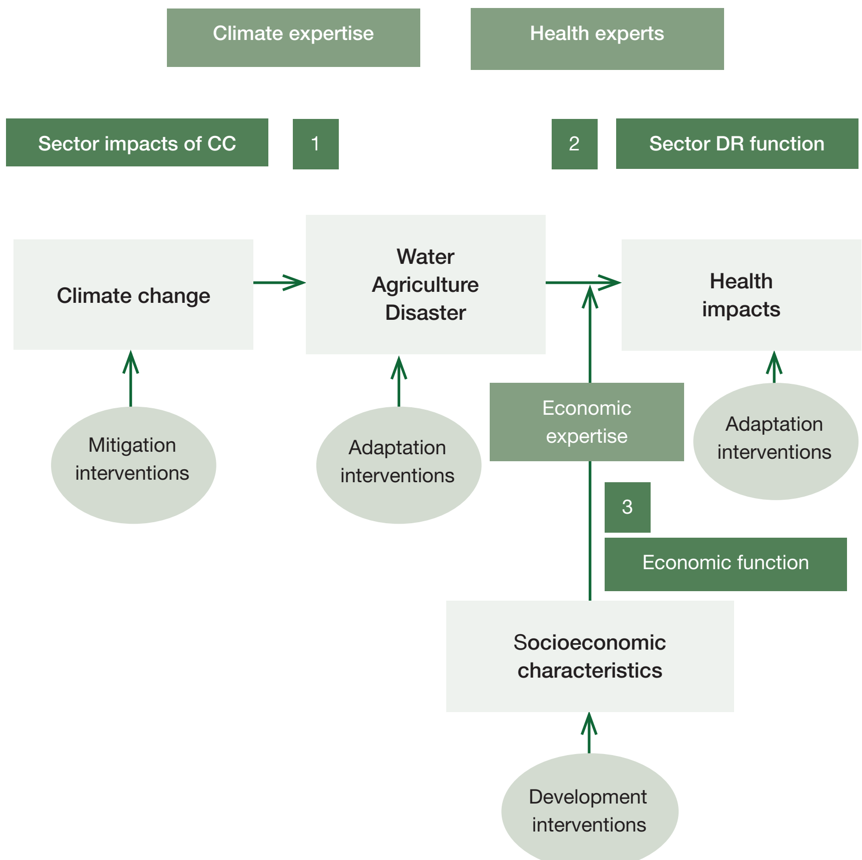
The challenging aspects of adaptation planning are the requirement of multidisciplinary skills and competencies. Options must be scientifically sound, socially beneficial, and economically viable. Roundtable discussions involve project engineers, environmental specialists, social safeguards experts, health experts, nongovernment organizations, implementing entities, and national climate change representatives. This is discussed in further details in the next section.

## A Collaborative Approach

Confalonieri et al. (2007) suggest the following major challenges for research on climate change and health must be addressed: (i) development of methods to quantify impacts of climate and weather on a range of health outcomes, particularly in low- and middle-income countries; (ii) development of health-impact models for projecting climate change–related impacts under different climate and socioeconomic scenarios; and (iii) investigations on the costs of the projected health impacts of climate change; effectiveness of adaptation; and the limiting forces, major drivers, and costs of adaptation. Of similar importance, the authors conclude that "there is a need to strengthen institutions and mechanisms that can systematically promote interactions among researchers, policymakers, and other stakeholders to facilitate the appropriate incorporation of research findings into policy decisions."

As shown in Figure 12, collaboration and coordination among different fields of expertise is required to reduce the uncertainty to health impacts of climate change.

## Figure 12 A Collaborative Approach




CC = climate change; DR = Dose Response.

Source: Figure created by author for this report.

# Conclusions and Recommendations

The study offers the following three key messages.

First, planning and implementing adaptation investments in the health sector is a significant component of an overall climate change adaptation strategy. To a large extent it remains an approach based on reacting to an increase in the health impacts of climate change, as opposed to preventing such increases. Sectors from which prevention of those health impacts can take place are water, agriculture, and management of disasters. A climate change adaptation strategy that focuses on preventing the projected health impacts of climate change is likely to be more effective in the short, medium, and long terms (with regard to both impacts and costs) than a strategy that is reactive.

Second, complementing the above message, health benefits of adaptation investments in the water, agriculture, and disaster risk reduction should be explicitly accounted for in the design stage when undertaking the economic analysis. Those benefits can inform adaptation investments taking into account the co-benefits of health. Lacking explicit consideration, the nature and extent of these adaptation investments are likely to be inappropriate (under-investment in adaptation and/or selection of inadequate adaptation options), and will result in health impacts and costs that could otherwise be avoided. There is a fundamental need to better understand the nature of the health impacts of climate change and of investment projects. Moreover, there is a need to better understand how to include health benefits and impacts of climate change in water, agriculture, and disaster risk reduction. Incorporating measures that produce health benefits in climate change–related sector development provides strong justification for multidisciplinary planning and coordination.

Third, climate and health experts and economists need to communicate more effectively to ensure that the information produced by one group of experts is of use to the others. Coordination and harmonization of methodologies, tools, and approaches are critical to support effective responses to climate change, particularly health benefits and impacts.

Specific recommendations to DMCs include the following:

(i) Incorporate health benefits and impacts of climate change into design, implementation, and monitoring processes in water-financing programs, agricultural projects, and disaster risk management systems.
(ii) Advocate for a policy dialogue ensuring integration of health impacts of climate change risks into national and regional development policies and strategies.
(iii) Improve public awareness, knowledge, and monitoring of co-benefits related to climate change, health, and economics to ensure reduce of poor people's vulnerability.
(iv) Strengthen national meteorological and/or hydrological services, disaster management systems, and national climate change offices to become more proactive to adapt to climate change, rather than reactive.
(v) With new projects, consider: (a) the provision of fellowships for education and training in climate modeling and impact studies, (b) the promotion of integrated climate studies in schools, and (c) support for the participation of least developed countries' experts in regional and international research activities.
(vi) Train district officials in facilitating community-based adaptation with a focus on preparedness and resilience, particularly related to "hot spots" or areas that are considered high risk (coastal areas and cities).

(vii) Establish a systematic observation network for short-term climatic monitoring, prediction, and assessment to be shared in regional climate programs for the explicit purpose of signaling possible outbreak of climate-related diseases (Box 5).
(viii) Provide high-quality data for impact assessment and adaptation activities, utilizing above observation network to monitor and implement responses related to extreme events.
(ix) Monitor systems for climate indices, extremes, trends, droughts, floods, sea-level rise, phenology, poverty, and other variables, as well as capacity and resources to maintain and use these systems to be available at the local and national levels. Information generated should reach and benefit the communities at the local level.

For its part, ADB can implement specific actions to address climate change and health, including:

(i) Support DMCs in preparing climate resilient sector road maps.
(ii) Help DMCs guide adaptation interventions that address health impacts and cost-effective responses.
(iii) Support knowledge generation and dissemination on evidence-based good practices on climate change and health.
(iv) Develop operational guidelines for health adaptation options.
(v) Work in partnerships to complement ADB's own capacities on climate change analyses and responses to health impacts.

### Box 5 Recommended Institutional Arrangements and Coordination in Nepal

In the changed political context, a health services network—including regional and/or federal level, district and/or local level, and community level with essential facilities for the health services delivery—should be established and its function and responsibility should be autonomous.

Public and private sectors for health service delivery should work in a complementary way. However, the public sector should formulate policy measures and create an environment that involves the private sector for effective delivery of health services.

The health organization should work in a coordinated and/or integrated manner with other agencies like the Ministry of Environment, Science and Technology; the Department of Hydrology and Meteorology; and the Department of Water Supply and Sewerage. The Ministry of Environment, Science, and Technology is the focal point for the United Nations Framework Convention on Climate Change (UNFCCC), while the Department of Hydrology and Meteorology is the focal point of the Intergovernmental Panel on Climate Change (IPCC).

The health sector requires formulating short- (5 years) and long-term (6–10 years) planning to address issues concerning climate change and health impacts. The short-term planning may include the development of surveillance and monitoring systems, the provision of safe water supply, sanitation (the elimination of open defecation), the use of alternative energy sources, the setting up of weather stations, resettlement, increased greenery, etc. Meanwhile, the infrastructure and facilities, early warning system, etc. may come under long-term planning. Awareness and dissemination, medication, preparedness, and monitoring and evaluation should be a part of continuous process. The issues should be identified based on research and participatory workshops.

The Ministry of Health and Population should be a lead agency to deal with the climate and health matters and coordinate all the activities with those organizations stated above. The Ministry of Environment, Science, and Technology should be the co-lead agency in this context. A Steering Committee of Climate Change and Health Impacts, led by the Ministry of Health and Population together with the Ministry of Environment, Science, and Technology as subcoordinator should be formed. Other agencies should be the members of the committee.

The following activities should be performed to address the issues in climate change and health impacts: (i) research and human resources development; (ii) database creation and communication; (iii) meetings, conferences, and workshops; (iv) formulation and implementation of policy measures and programs; (v) information gathering and dissemination; and (vi) monitoring and evaluation.

Source: Pradhan, B. 2010. Key Sector Analysis: Health Adaptation in Nepal. Mimeo. Kathmandu.

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**Accounting for Health Impacts of Climate Change**

Climate change will affect health in most countries in Asia and the Pacific. It will challenge the public health community at the global, regional and national levels with emerging diseases and existing diseases increasing and spreading geographically. This study aims to improve the understanding of the human health dimensions of climate change and how projects in areas other than health, such as agriculture, water financing programs, and disaster risk reduction need to account explicitly for the health impacts of their interventions.

**About Swedish International Development Cooperation Agency**

Sida works according to directives of the Swedish Parliament and Government to reduce poverty in the world, a task that requires cooperation and persistence.

Through development cooperation, Sweden assists countries in Africa, Asia, Europe and Latin America. Each country is responsible for its own development. Sida provides resources and develops knowledge, skills and expertise. This increases the world's prosperity.

**About the Asian Development Bank**

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to two-thirds of the world's poor: 1.8 billion people who live on less than $2 a day, with 903 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

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