Energy & Ethics

Justice and the Global Energy Challenge

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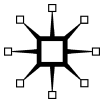

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Intragenerational Equity and Climate Change Adaptation

Introduction

Our global energy system is unjust because it emits greenhouse gases into the atmosphere, which then damage communities and countries that, given their primarily agrarian economies, contributed the least to those emissions.[1] Even worse, these emissions will likely harm existing and future generations with a collection of grave consequences such as rising food insecurity, the proliferation of climate refugees, and an increased frequency and severity of natural and humanitarian disasters. The buffering capacity of the planet requires that we radically reduce our emissions at the same time that the energy needs of the world are crying out for a vast increase in the distribution of energy (see Chapter Seven for more on that). Fortuitously, community-based adaptation measures provide developed and developing countries alike a way out of this quagmire. The Global Environment Facility's (GEF) Least Developed Countries Fund (LDCF) offers an exemplary model for how these adaptation projects can be implemented. It has, as of late 2012, disbursed $602 million in voluntary contributions in support of 88 adaptation projects across 46 countries.

Intragenerational equity as an energy justice concern

Because climate change is such a wide-ranging and complex threat, it cuts across multiple justice concepts and dimensions. The impacts of climate change will be distributed unevenly due to both physical processes and the different adaptive capacities of communities and countries; also, historically only a small group of countries is responsible for the largest chunk of these emissions.[2] Justice expert Gordon Walker writes that:

> Climate change makes the most persuasive case for a justice framing. With climate change we are confronted with evidence of patterns of inequality and claims of environmental injustice that span the globe,

> that permeate daily life and which pose threats to the current and future health and well-being of some of the poorest and most vulnerable people in the world. Climate change demands more than ever that we think rationally about how things interconnect, about who benefits at the expense of others, and about the spatially and temporally distant impacts of patterns of consumption and production. The consequence is that, for many already economically, politically, and environmentally marginalized people, climate change presents compounding forms of injustice.[3]

This makes the issue of climate change about fairness. As University of East Anglia climate expert W. Neil Adger and his colleagues write, "fairness is essential to reaching any meaningful solution to the problem of climate change during this century."[4] But fairness based on what, and to whom?

Modern justice theorists advance at least two interrelated answers: an argument about future generations, and an argument about human and subsistence rights. First, climate change raises justice concerns for future generations in a variety of ways. Failing to mitigate emissions today will inflict actual harm on future people when those emissions produce dangerous changes in climate.[5] The climate-related impacts of past and current greenhouse gas emissions could last longer than Stonehenge, time capsules, and perhaps even high-level nuclear waste. For each ton of carbon dioxide we leave in the atmosphere today, one-quarter of it could still be affecting the atmosphere one thousand years from now.[6] Once emitted, a ton of carbon dioxide takes a very long time to process through the atmosphere – according to the latest estimates, one-fourth of all fossil-fuel-derived carbon dioxide emissions will remain in the atmosphere for several centuries, and complete removal could take as long as 30,000 to 35,000 years.[7] Put another way, the climate system is like a bathtub with a very large tap and a very small drain.[8]

Consequently, "future generations will be more severely damaged by climate change than present generations – indeed, they will be its greatest victims, especially in the relatively near future before physical and psychological adaptations can set in for the lucky."[9] University of Tennessee philosopher John Nolt has gone so far as to frame the current situation as equivalent to the "enslavement" of future generations. He writes that "our emissions of greenhouse gases constitute unjust domination, analogous in many morally significant respects to certain historic instances of domination that are now almost universally condemned, and, further, no benefits that we may bequeath to the future can nullify the injustice."[10]

Second, like the situation of energy access and energy poverty discussed in Chapter Seven, climate change raises justice issues on human rights grounds. Justice theorist Henry Shue has argued compellingly that, if physical security is a basic right, then so are the conditions that create it, such as employment, food, shelter, and also unpolluted air, water, and other environmental goods, something he calls "subsistence rights."[11] The implication is that such people

Table 8.1 Criteria and indicators for Shue's "Standard of Decent Living"

Basic Goods	Energy Service(s)	Standard for Decent Living
Food	Cooking energy, methane	Adequate nutrition, 2 MJ/cap/day
Water/Sanitation	Heat for boiled water	50 liters potable water/month
Shelter	Floor space, lighting, space conditioning	10 square meters of space, 100 lumens per square meter light, 20 to 27 degrees C temp
Health care	Electricity	70-year life expectancy
Education	Lighting and electricity	
Clothing	Mechanical energy for weaving	
Television	Electricity	~100 kWh per month for all household appliances
Refrigerator	Electricity	
Mobile phone	Electricity	
Mobility	Personal vehicle	Motorized transport

Source: Adapted from Shue.

are therefore entitled to a certain set of "goods" that enables them to enjoy a basic minimum of well-being, shown in Table 8.1; included in this set of goods is the right to "subsistence emissions." As Shue puts it, "Basic rights are the morality of the depths. They specify the line beneath which no one is allowed to sink."[12]

In sum, these complementary notions of protecting future generations and ensuring subsistence rights mean that "distance makes no moral difference in our globalized world; individual high emitters have a duty to reduce their emissions, wherever they are."[13] It means, moreover, that when some people have less than enough for a decent human life, and other people have more than enough, an adequate minimum must be set for those who need to meet a basic standard of living.[14]

Unfortunately, the pending impacts of climate change directly threaten our ability both to protect future generations and to meet our subsistence obligations. Though not a complete list, six climate-related impacts will likely be most severe: ocean acidification, more frequent and intense disasters, mass climate refugees, food production, disease epidemics, and shortages of water.

Ocean acidification

Due almost completely to emissions of carbon dioxide, the acidity of the oceans has increased about 30 percent since the time of the Industrial Revolution, the greatest rate of increase in the past 55 million years – posing serious threats to countries in Asia and Africa that mostly depend on fish for their food. At the base of the marine food chain, acidification is rapidly

depleting algae and plankton. Increased acid is bleaching and damaging coral reefs. For example, clown fish are especially susceptible to acidification as they will lose their ability to "smell." Acidification is interfering with the reproductive processes of brittle stars, which is in turn shrinking stocks of herring. It is also causing a decline in the levels of aragonite and calcium carbonate, key to almost all marine skeletons and shells.

Rather than being limited in scope, the threats from acidification are global, with the greatest degree of acidification in the Atlantic, north Pacific, and Arctic seas, each a crucial summer feeding ground for billions of organisms.[15] Recent scientific studies warn that climate change will likely lead to numerous local extinctions and drastic species turnovers (invitation to and extinction from an area) affecting more than *60 percent* of all marine biodiversity, as well as declines in the vitality of coral reefs due to bleaching, diseases, and tropical storms – with roughly *one-third* of all coral reefs at risk of becoming extinct.[16] If allowed to run its course, such acidification could turn the shining sea into a "carbon cesspool."[17]

Natural and humanitarian disasters

Climate change is increasing the frequency and severity of natural and humanitarian disasters. Global economic damages from natural catastrophes, most of them related to climate change, have doubled every ten years and reached about $1 trillion over the course of the past two decades. Hurricane Sandy, which recently flooded parts of New Jersey and New York in October 2012, caused up to $50 billion in damages to New York (and that's excluding the destruction in its wake across the Bahamas, Cuba, Dominican Republic, Haiti, Puerto Rico, and in other parts of the U.S.).[18] Annual weather-related disasters have increased by a factor of four from 40 years ago, and insurance payouts have increased by a factor of 11, rising by $10 billion each year for most of the 1990s.[19] In Colombia, for example, changing precipitation patterns, more extreme weather events, hurricanes and flooding, stronger cycles of El Nino and La Nina, and increases in sea level both threaten coasts and will challenge the vitality of low-lying urban centers.[20] In Bolivia and parts of Latin America, flooding from storms is expected to contribute to landslides that result in thousands of deaths and the spread of diseases.[21] In the Maldives, about half (44 percent) of all human settlements and 70 percent of all critical infrastructure are within 100 meters of the sea. These settlements are already at risk from rising sea levels, storms, and floods. Severe weather events from 2000 to 2006 flooded 90 inhabited islands at least once and 37 islands repeatedly. Sea swells in 2007 inundated 68 islands in 16 atolls, destroyed 500 homes, and necessitated the evacuation of 1,600 people.[22]

Mountainous areas around the world, from the Alps in Europe to the Himalayas in Asia, also face the aggravated risk of glacial lake outburst floods – when glaciers melt faster than expected and produce massive, spontaneous releases of water capable of killing thousands of people and

destroying entire cities. The United Nations Environment Program and the International Center for Integrated Mountain Development have identified no fewer than 24 high-risk glacial lakes near Bhutan and Nepal.[23] Melting glaciers will flood river valleys in Kashmir and Nepal to the point where 182 million people could die of the resulting disease epidemics and starvation.[24] In Africa, rising sea levels could destroy as much as 30 percent of the continent's entire coastal infrastructure.[25]

The United States Department of Defense has simulated the probable effects of climate change and has begun preparing for a future world where droughts and periods of extreme heat increase in the Southwestern United States and Mexico; where the intensity of hurricanes increases on the US coast and in the Caribbean basin; where ice storms become more difficult to deal with in New England and Eastern Canada; where large mudslides and flooding occur in Central America; where massive wildfires cause deforestation, flooding, and siltification not only in California, Washington, and Canada, but also in Argentina and Brazil; and where the Philippines, India, Bangladesh, Vietnam, and China respond to typhoons and cyclones that severely damage coastal cities.[26]

Food security

Climate change has grave implications for the production, processing, and distribution of food, with particularly severe impacts in Africa and Asia. According to one study published in the *Lancet*, by 2080 as many as 40 least developed countries with a total population of three billion people could lose 20 percent of their cereal production. Alterations to the ranges of agricultural pests and diseases with warming winters could cause infestations of locusts, whiteflies, and aphids that could create "extensive losses of crop yields." Over the past three decades precipitation across the Sahel in Africa has declined by 25 percent, contributing to hunger and malnutrition in the Niger Delta, Somalia, and Sudan. Some experts anticipate severe climate-induced shortages of food in Angola, Burkina Faso, Chad, Ethiopia, Mali, Mozambique, Senegal, Sierra Leone, and Zimbabwe that will starve 87 million people.[27] Another study warned that as many as 75 to 250 million people in Africa could be exposed to increased water stress by 2020 as yields from rain-fed farms fall by 50 percent.[28]

Countries in the Asia Pacific will also be hit hard. Some states, such as Maharashtra, India, are projected to suffer greater drought that will likely wipe out 30 percent of food production, inducing $7 billion in damages among 15 million small and marginal farmers.[29] In India as a whole, farmers and fishers will have to migrate from coastal areas as sea levels rise and they confront heat waves lowering crop output and manage declining water tables from saltwater intrusion.[30] In China, higher temperatures and increased evaporation rates for soil are expected to result in a ten percent overall increase in the water needed for agriculture, and farms will likely become more vulnerable to insects and pests, resulting in declining yields.[31]

In Laos, the government anticipates that almost half (46 percent) of the rural population will risk food insecurity due to loss of access to farmland and natural resources caused by a combination of flooding, droughts, and rising prices.[32] In Bhutan, farmers have already reported instabilities in crop yields, losses in production, declining crop quality, and decreased water available for farming and irrigation. Moreover, they have documented loss of soil fertility from erosion and runoff, delayed sowing of crops due to premature frost, and outbreaks of new pests and diseases.[33] In Bangladesh, home to 150 million people, higher temperatures and changing rainfall patterns, coupled with increased flooding and rising salinity in the coastal belt, are likely to reduce crop yields and crop production, taking their toll on food security. Some studies even calculate the likelihood of a 17 percent loss in overall rice production and as much as a 61 percent decline in wheat production in the next few decades; they caution that any positive increases in yield will be more than offset by moisture stress.[34]

Human health and diseases

The World Health Organization believes that climate change has already killed 150,000 people in 2000 and subjected a further 5.5 million people to years of lost life due to debilitating diseases; most of these instances have been in the developing world. More worryingly, the WHO projects at least a *doubling* in deaths and burden in terms of life years lost by 2030 due to heat-related illnesses, illnesses from floods, droughts, and fires, changing vector patterns, and loss of biodiversity.[35] In China, climate change will in all likelihood alter disease vectors and create conditions for pandemics, as increases in temperature and decreases in availability of water expand the range and frequency of malaria, dengue fever, and encephalitis.[36] In the Maldives, waterborne diseases such as shigella and diarrheal diseases have also become more pronounced in children under the age of five, spread by an increase in flooding. Indirectly, climate change has contributed to malnutrition and limited the accessibility and quality of health care, with storms and floods making it more difficult to distribute food or transport patients to doctors.[37] In low-lying river deltas throughout the world, flooding and cyclones will directly affect health and nutrition by causing physical damage and disruptions in the supply of food and basic services, and indirectly by spreading waterborne diseases and creating prolonged periods of malnutrition. During the monsoon season in 2004 in Bangladesh, for example, flooding placed 60 percent of the country under a solid pool of water mixed with industrial and household waste. More than 20 million people suffered shortages of water, skin infections, and communicable illnesses.[38]

Water quality and availability

The water-related impacts from climate change will probably be just as egregious, encompassing reduced access to freshwater, less water for irrigation, less drinking water, and improper sanitation. Changes in rainfall, snowfall,

snowmelt, and glacial melt could put 40 percent of the world population at risk – since they depend on mountain glaciers for their water supply. Several of the world's major rivers, including the Indus, Ganges, Mekong, Yangtze, and Yellow, start from glaciers. Storm surges also threaten to contaminate water with saltwater.[39] By 2080 increased floods, droughts, and storm surges could all lower water availability and quality and affect 1.5 billion people.[40]

Climate refugees

Global climate change's impending threats will push many families out of their homes. These climate refugees must relocate due to the many impacts discussed above. According to the Environmental Justice Foundation, "[e]very year climate change is attributable for the deaths of over 300,000 people, seriously affects a further 325 million people, and causes economic losses of $125 billion."[41] A separate study calculated that by 2050 more than 200 million people could lose their homes due to climate change.[42]

While environmental calamities have been common throughout the ages, the world's population intensifies the scope of the climate refugee problem; as the *New York Times* explains, "with the prospect of worsening climate conditions over the next few decades, experts on migration say tens of millions more people in the developing world could be on the move because of disasters."[43] Similarly, small island developing states such as the Maldives and the Seychelles could be completely submerged within 60 years if sea levels continue to rise. The Republic of Kiribati, a small island country in the Pacific, has already had to relocate 94,000 people living in shoreline communities and coral atolls to higher ground.[44] The Republic of Maldives could lose 80 percent of its land due to rises in sea level and has already started purchasing land in Sri Lanka for its climate refugees.[45]

Community-based adaptation

Community-based adaptation measures offer perhaps the best tool enabling us to meet our climate change justice obligations. The term "adaptation" describes adjustments in natural or human systems in response to the impacts of climate change.[46] The Intergovernmental Panel on Climate Change defines "adaptive capacity" as the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.[47] Adaptation is "community-based" when implemented by local stakeholders, and it is sometimes called "anticipatory adaptation" when it tries to preempt particular risks.[48] Most adaptation efforts are targeted towards enhancing "resilience," the amount of disturbance a local system, climatic or social, can absorb and remain within the same state.[49] Table 8.2 illustrates three of the most salient types of resilience.

Table 8.2 Dimensions of resilience and adaptive capacity

Type of Resilience	Explanation	Dimensions
Infrastructural	Refers to the assets, infrastructure, technologies, or "hardware" in place to ensure the delivery of services that could be disrupted by climate change (such as electricity or water)	Resilient infrastructures tend to encompass relevance, flexibility, and diversification
Institutional	Refers to the endurance of an institution or set of institutions, usually government ministries or departments, in charge of planning and community and infrastructural assets	Resilient institutions are strong; they can cope with new stresses and changes and maintain their core function and purpose. They tend to have permanence, rapidity, and legitimacy
Community	Refers to the cohesion of communities and the livelihoods of the people that compose them	Resilient communities tend to possess ownership, wealth, education, and access to knowledge and education that enable them to make decisions and respond to climate-related challenges

As the case study of the LDCF below shows, adaptation efforts are necessary if communities are to respond to drastic changes in climate once tipping points, such as acidification of the ocean, alteration of the Gulf Stream, or thawing permafrost, are crossed, and adaptation can also have a high relevance regarding slow or gradual changes in climate.[50] Furthermore, adaptation efforts tend to be "win-win situations," for they not only improve resilience to climate change but often spill over into ancillary benefits such as economic stability, improved environmental quality, community investment, and local employment.[51]

Case study: The GEF's Least Developed Countries Fund

Established in 2001, the GEF's LDCF was created exclusively to help the poorest countries in the world prepare and implement National Adaptation Programs of Action (NAPAs) to reduce the pending impacts of climate change. Currently one of the world's largest funds for climate adaptation, the GEF has so far leveraged $602 million in voluntary contributions to support 88 adaptation projects in 46 countries (as of November 2012), projects implemented in tandem with partner agencies including the World Bank, United Nations

Development Program, and Food and Agriculture Organization. As the GEF explains, the LDCF is "seminal in climate change adaptation finance" and is the "first and most comprehensive adaptation-focused program in operation for least developed countries."[52]

The Fund is special because, as the name implies, it is dedicated almost entirely to the 48 countries belonging to the group of "least developed," meaning they have low incomes (less than about $900 per capita per year), weak human assets, and high economic and social vulnerability. Least developed countries lack the requisite capacity to implement adaptation projects. While the city of Perth in Western Australia can build a desalination plant to offset losses in water due to declining precipitation and increasing drought; planners in the Netherlands can construct dikes, dams, and floating houses to cope with increased flooding and rises in sea level; and the city of London can invest in a Thames River barrier system to better respond to floods, some of the world's poorest areas have no resources to implement adaptation projects on their own.[53] Least developed countries depend on climate-sensitive sectors such as agriculture, tourism, and forestry, meaning changes in temperature and precipitation and extreme weather events affect them more viscerally than others. They are also, for a variety of geographic and economic reasons, located in regions at the greatest risk of rising sea levels, deteriorating ecosystem services, social tensions, and the creation of environmental refugees.[54]

History

The LDCF arose out of the Seventh Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP7), held in Marrakesh, Morocco, in 2001. The GEF was placed in charge of this "financial mechanism" for climate change and the World Bank was established as its "Trustee." As Table 8.3 shows, the LDCF is one of five major multilateral funds for adaptation projects.[55] The LDCF has a governing body which meets twice a year. The LDCF supports two key activities: the preparation of NAPAs, policy documents assessing climate-related risks for particular countries; and the implementation of adaptation projects prioritized according to each country's specific NAPA. All least developed countries are eligible for the fund – it operates according to the principle of "equitable access" rather than "first come, first served," though proposals are formally evaluated based on their country of origin, conformity with existing national policies, and institutional support, among other criteria.[56]

Since its creation, as of June 2012 – the last time formal numbers were released – the LDCF has funded the completion of 48 NAPAs and the implementation of 74 projects and one program across 44 countries, totaling $334.6 million and leveraging $1.6 billion in co-financing (rising to $602 million, 88 projects, and 46 countries by the end of the year).[57] As Figure 8.1 illustrates, these projects have focused on reducing vulnerability across a

Table 8.3 Funds for adaptation under the United Nations Framework Convention on Climate Change Regime

Fund	Created under	Global environmental benefits	Beneficiaries	Funding sources
GEF Trust fund	UNFCCC	Incremental cost to achieve global environmental benefits	Developing countries	GEF
GEF Strategic Priority for Adaptation (SPA)	UNFCCC	Incremental cost to achieve global environmental benefits	Developing countries	GEF
Special Climate Change Fund (SCCF)	UNFCCC	Additional costs of adaptation measures. Uses a sliding scale	Developing countries	Developed countries discretionary pledges
Least Developed Countries Fund (LCDF)	UNFCCC	Additional costs of adaptation measures. Uses a sliding scale	Least developed countries	Developed countries discretionary pledges
Adaptation Fund (AF)	Kyoto Protocol	No	Developing countries	Share of proceeds from CDM; other sources

Source: Adapted from United Nations Framework Convention on Climate Change and Grasso. CDM refers to the Clean Development Mechanism.

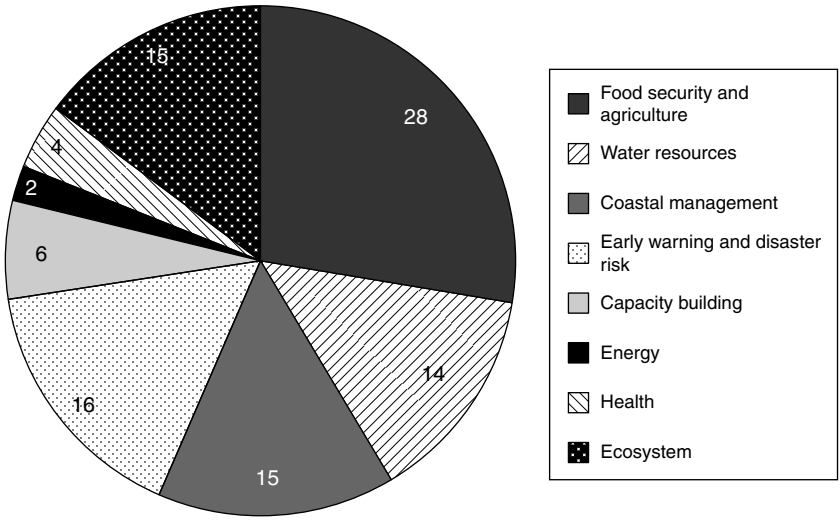

Figure 8.1 Development sectors prioritized in National Adaptation Programs of Action (as of June 2012)

Source: Global Environment Facility.

variety of sectors, including early warning and natural disasters, agriculture, and fragile ecosystems. Figure 8.2 documents how, as of June 2012, some $537 million had been pledged to the LDCF from countries such as Germany, the United Kingdom, the United States, and Sweden, among others.

Because covering all 88 projects would make this chapter excessively long, it focuses mostly on four major efforts being implemented in Asia and summarized in Table 8.4: coastal afforestation in Bangladesh, glacial flood control in Bhutan, agricultural production in Cambodia, and coastal protection in the Maldives.

Bangladesh is prone to a multitude of floods, droughts, tropical cyclones, and storm surges. Fifteen percent of its 162 million people live within 1 meter's elevation from high tide. In 1991, a particularly devastating cyclone with winds stronger than 200 kilometers an hour and a tidal surge of 6 meters claimed 140,000 lives and induced $240 million in damages.[58] Such climatic vulnerabilities are only compounded by a high incidence of poverty and heavy reliance on agriculture and rural forestry. Rising sea levels place more than 40 million people at direct risk of saltwater intrusion of water supplies for drinking and irrigation, and the ever-present occurrence of floods from drainage congestion and severe storms.[59]

To respond to these threats, the Ministry of Environment and Forests is aiming to reduce the vulnerability of coastal communities to the impacts of climate change by carrying out LDCF-sponsored afforestation in four *upazilas* (translated as sub-districts) in the coastal districts of Barguna and Patuakhali (Western region), Chittagong (Eastern Region), Bhola (Central Region), and Noakhali (Central Region). Project managers selected sites on

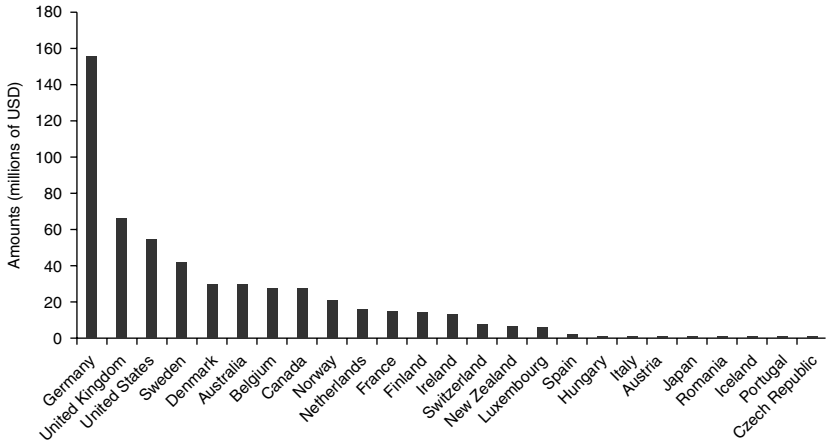

Figure 8.2 Least Developed Country Fund pledges by country (as of June 2012)
Source: Global Environment Facility.

Table 8.4 Examples of Least Developed Countries Fund projects in Asia

Sector/Type of Adaptation	Country	Budget	Duration	Primary Actors	Description
Coastal Afforestation	Bangladesh	$10.8 million	March 2009 to February 2013	United Nations Development Program; Forest Department at the Ministry of Environment and Forestry	Utilizes community-based afforestation, mangrove regeneration and plantation management, erosion prevention, and the deployment of coastal sediment barriers to reduce climate vulnerabilities in four upazilas in the coastal districts of Barguna, Patuakhali, Bhola, Noakhali, and Chittagong
Glacial Flood Control and Early Warning Systems	Bhutan	$8.3 million	March 2008 to February 2013	United Nations Development Program; Department of Geology and Mines at the Ministry of Economic Affairs; Disaster Management Division of the Ministry of Home and Cultural Affairs	Implements a disaster management plan and will demonstrate technologies available to reduce glacial lake outburst floods from the Thorthormi glacial lake in the Punakha-Wandgi Valley and Chamkhar Valleys
Coastal Protection	Maldives	$9 million	March 2010 to February 2013	United Nations Development Program; Ministry of Environment, Energy, and Water	Establishes a climate information system to collect and disseminate knowledge about climate vulnerability and designs a migration plan of Safer Islands to which communities at threat can relocate
Agriculture	Cambodia	$4.4 million	July 2009 to June 2013	United Nations Development Program; Ministry of Agriculture, Fisheries and Forestry; Ministry of Water Resources and Meteorology	Trains engineers in climate-resilient irrigation design (including reservoirs, irrigation canals, ponds, and dykes) and establishes a community-based climate information system on floods and droughts

Source: Global Environment Facility.

the basis of their projected vulnerability and also through public participation. The project has four primary components. The first is implementing interventions that generate income and couple afforestation with community livelihood. The second is enhancing national, sub-national, and local capacities of government authorities and sectoral planners so that they better comprehend climate risk dynamics in coastal areas and implement appropriate risk reduction measures. The third is reviewing and revising coastal management practices and policies. The fourth is developing a functional system for the collection, distribution, and internalization of climate-change-related data.

In Bhutan, the acceleration of glacial melting has compounded the risk of Glacial Lake Outburst Floods (GLOFs). Glacial lakes there hold tens of millions of cubic meters of water and can release high volumes in minutes, devastating valleys and communities downstream. Major sectors of the economy involve agriculture, livestock, and forestry, but these have become situated in close proximity to flood paths. One inventory identified 25 glacial lakes at "high risk" of a GLOF, with 12 located in the Pho Chhu and Chamkhar Chu sub-basins, home to more than 40 Bhutanese villages and towns with tens of thousands of residents.[60]

In response, the government launched the LDCF-funded GLOF project to tackle disaster risks. It has three primary components. A component focused on lowering of lake water levels is being undertaken by the Department of Geology and Mines (DGM) to reduce the risk of GLOFs at two glacial sites in the Himalayas. So far mitigation work by DGM has focused only on one lake, Thorthormi, where it is aiming to reduce the lower lake's water level by 5 meters, enough to eliminate hydrostatic pressure on its unstable moraine dam. An early warning component is being led by the Department of Energy, and a third community awareness component is attempting to increase knowledge about climate change among community leaders and rural policymakers.

In Cambodia, droughts and floods have already caused substantial human and crop losses and are widely viewed as a prelude to more extreme weather. Rice, Cambodia's largest crop by volume and value, is forecasted to suffer yield losses of 5 percent over current levels in 2020 under IPCC scenarios. Annual rainfall is projected to increase in some areas, but, when coupled with increased variability and ambient temperatures, yield losses will worsen through 2080 and potentially turn Cambodia into a net rice importer.[61]

Planners there are, therefore, focusing on building adaptive capacity with LDCF resources for water management and agriculture. They are enhancing the ability of local government and communities to integrate long-term climate risks into policy and decision-making related to subsistence farming and rice paddy production. Many of the communities living in the targeted districts in Preah Vihear and Kratie practice subsistence farming and are reliant on agriculture for their livelihoods. Adaptation efforts are focusing

on educating these farmers and local leaders about climate change, and also strengthening infrastructure such as irrigation channels and ponds.

Geographic and geophysical traits, such as small size, low elevation, narrow width, and dispersed nature of coral islands and reefs, make the Maldives especially vulnerable to rainfall flooding and ocean-induced flooding. About half the country's human settlements are within 100 meters of the shoreline, along with almost three-quarters of its critical infrastructure, including airports, power plants, landfills, and hospitals. The Maldives is the "flattest country on earth" and "extremely vulnerable" to climate change, so much so that 85 percent of its geographic area could be underwater by the year 2100 if sea levels rise under more extreme projections.[62]

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

Benefits

As this section documents, these four particular LDCF projects are producing four sets of distinct benefits: (1) strengthening nationally significant infrastructure, (2) enhancing institutional capacity and awareness, (3) improving community assets, and (4) producing benefits that exceed costs.

Strengthening infrastructure

Each of the four LDCF projects enhances physical and infrastructural resilience in some way. Bangladesh's coastal forest today is almost a monoculture of mangroves. These monoculture forests have a limited ability to mitigate the impacts of climate change as they have been prone to pest outbreaks, deforestation, and logging. Historically, Bangladesh had a 500-meter buffer of mangroves to reduce the shocks of incoming storms and monsoons, but this has now been reduced to 12 to 50 meters in most locations. Attacks by the stem borer pest have felled thousands of hectares, and illegal deforestation and logging have made matters worse. The project in Bangladesh addresses this problem and sponsors 6,000 hectares of community-based mangrove plantations, 500 hectares of non-mangrove mount plantations, about 220 hectares of dykes, and more than 1,000 kilometers of embankments. The Bangladesh project is also developing early warning information and disaster preparedness systems in vulnerable areas to protect at least 20 villages and towns.

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

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

In the Maldives, planners have moved away from exclusively building capital-intensive sea walls and tetrapods to bolster infrastructural adaptation by replenishing natural sea ridges, planting mangroves and vegetation on shorelines, and raising the height of water storage tanks so they are no longer susceptible to sea swells and saltwater intrusion. The government has started propagating new coral reefs around Thulusdhoo and Kudhahuvadhoo and adopting beach nourishment activities to mitigate flooding. Planners are deploying what they call "soft" adaptation infrastructure. As one government official told the author:

> The key to the [project] is moving beyond hard infrastructure to soft protection, using ecosystems and trees as measures to improve resilience that are cheaper, environmentally more sound, and longer lasting than their capital- and technology-intensive counterparts. The sea wall around Malé, for example, cost $54 million to erect, or $12.4 million per kilometer. The Maldives has 2,002 kilometers of coastline, which would make protecting them all with a seawall a monumental $24.8 billion enterprise. With the country's current annual GDP, it would take more than three decades to raise the funds for such a task, let alone build the sea wall. We've also got only $9 million in total to work with for the [project]. What are we going to do, build half a kilometer of sea wall with [our LDCF] money?

This comment implies that one of the more innovative ways the project strengthens resilience is by deploying smaller-scale, less capital-intensive "soft" measures such as planting mangroves or improving coastal vegetation, instead of building more of the "hard" and expensive seawalls like the one shown in Figure 8.3.

Figure 8.3 The $54 million tetrapod seawall surrounding Malé, Maldives

Enhancing institutional capacity

Adaptation efforts in our four LDCF projects prioritize not only infrastructure but also improving institutions and propagating standards of good governance. In Bangladesh, the government provides free training sessions for local level administrators in disaster management and also facilitates input from civil society and community members in the formulation of state and national policies and regulations.

In Bhutan, training for government planners is intended to build institutional capacity. The project has sponsored the training of geologists and employment for civil engineering work, and funded the creation of community-based disaster management committees, whose job it is to highlight hazards and form district disaster management teams at village levels.

In Cambodia, their LDCF project is encouraging community development plans based on long-term climate forecasts and scenarios, budgeting for water resources investments that are appropriate for the anticipated risks. In addition to devolving ministerial functions to local levels where possible, the project has shifted responsibility for planning onto community groups. The project thus empowers commune councils, farmer water user communities, and planning and budget committees to play a more active role in adaptation projects.

In the Maldives, institutional capacity is being strengthened through the training of government officials in risk analysis, hazard mitigation, and land use planning. By 2014 the goal is to train at least 12 senior decision-makers and planners from national ministries in Malé, as well as all senior decision-makers in four provinces and atolls. Part of this component involves participating with local island leaders to share knowledge and

learn about local efforts at deploying some of the "soft" adaptation measures described above.

Improving community assets

Each LDCF adaptation project enhances community and social resilience. In many parts of the coastal forests of Bangladesh, the average annual per capita income is less than $130, a fraction of the national average, rendering people completely dependent on wetlands and coastal forests to meet their subsistence needs.[63] To counter this incentive to damage forests for their survival, the LDCF project is disbursing revenues to vulnerable coastal communities so that they can diversify income sources and occupational training. One especially innovative dimension of this component is its focus on the "Triple F" model of "Forest, Fish, and Food." The coastal communities most vulnerable to rising sea levels – the places where mangroves need to be planted and forests replenished – are also those where farming and forestry are the primary sources of income. The "FFF" model attempts to maintain community livelihood and adapt to climate change at the same time by integrating aquaculture and food production within reforested and afforested plantations.

In Bhutan, a community awareness sub-component is being implemented in Punakha, Wangdi, and Bumthang. Officials are creating a zoning map to mark several safe evacuation areas and extremely unsafe zones, and setting up emergency operation centers at district administration offices to enable them to better handle crises. Communities are being trained in their response to calamities and emergency situations using mobile phones and radio broadcasts in addition to traditional sounding gongs and bells from monasteries. Figure 8.4, for example, shows posters depicting first aid and emergency response techniques in the case of a GLOF. These efforts will give communities a better understanding of the risks and hazards surrounding GLOF occurrences. This information also enables communities to better plan for where to locate infrastructure, homes, and farmland.

In Cambodia, in addition to devolving ministerial functions related to adaptation efforts to local levels where possible, millions of dollars of funds have been transferred to fund the agricultural adaptation projects selected by village planning committees.

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

Figure 8.4 A Bhutanese Department of Disaster Management poster on glacial lake outburst floods

Positive cost curve

Though certainly simplistic, there are three ways that one can argue the LDCF has a positive cost–benefit curve. The first is based on its likely, positive impact in the future. The Asian Development Bank estimates that every $1 invested in climate change adaptation in 2010 could yield as much as $40 in economic benefits by 2030.[64] Presuming this to be the case for LDCF case studies – an admittedly crude way of calculating things – the $537 million so far pledged by the LCDF for adaptation projects around the world will culminate in $21.5 billion in economic benefits.

Second, though, is the cost of the LDCF's mitigation of emissions. Though adaptation rather than mitigation is its primary goal, its portfolio of projects actually mitigates emissions as an ancillary accomplishment. One study estimated that the GEF avoids or prevents carbon dioxide emissions from entering the atmosphere for a cost less than $2 per ton.[65] Noted economist Richard Tol has meticulously tracked the difficulties in ascertaining the marginal damage cost of carbon dioxide, but has synthesized data from dozens of reputable sources and concludes that it is somewhere between $14 and $93 per ton.[66] Economists working for the US federal government, hardly a source biased in favor of prudent climate policy, have similarly harmonized results from three integrated assessment models examining five socio-economic scenarios with three fixed discount rates and concluded that

the cost of a ton of carbon dioxide ranges from $4.70 to $64.90 in 2010 and $11.20 to $109.70 for 2035.[67] Economists Frank Ackerman and Elizabeth Stanton from the Stockholm Environment Institute report that the real social cost of carbon could be as much as $1,000 per ton by 2050.[68] These varying figures mean that the GEF's actions displace carbon dioxide 2.35 to 500 times more cheaply than its actual cost.

A third way the LDCF has a positive cost curve is its ability to leverage more money than it spends. In late 2011, when the Australian Government was conducting an independent assessment of the LDCF, it noted that the LDCF leveraged $919 million in co-financing, more than $4.20 for each dollar contributed by the fund.[69] The most recent publicly available data from June 2012 reports $334.6 million spent and $1.56 billion leveraged in co-financing, meaning each LDCF dollar raised $4.66 towards climate change adaptation.

Challenges

Though these benefits are significant, the LDCF also faces four challenges: (1) insufficient and uncertain funding, (2) a convoluted management structure, (3) the complexity of adaptation projects within the context of LDCs, and (4) an inability to eliminate some of the most meaningful climate-related risks.

Insufficient and uncertain funding

Because the LDCF is supposed to prioritize "equitable access" for all participating countries, individual projects have a "ceiling" on the amount they support. For instance, from 2001 to 2006 the cap on LDCF projects was $3.5 million, in 2008 it was raised to $6 million, in 2010 it was increased to $8 million, and today it is $20 million. Though the LDCF has a mandate to finance the full additional cost of adaptation, without a requirement for matching co-financing, in practice the ceiling inadvertently requires hosting governments to co-sponsor projects, or find other institutions such as the United Nations Development Program (UNDP) or Food and Agricultural Organization (FAO) to "match" contributions. Moreover, because the LDCF is voluntary, it is only replenished when donor countries decide to be generous, making it difficult to accurately predict the amount of resources available to countries over long timeframes.[70]

Furthermore, the LDCF is clearly insufficient to ensure the implementation of all needed adaptation projects. As noted earlier, so far the fund has leveraged slightly more than $600 million, yet the immediate adaptation needs of LDCs total at least $3 billion.[71] In 2007, even when the LDCF is combined with three other large multilateral funds, the amount spent on adaptation equaled about $283 million pledged and $32.8 million disbursed, rising to $711 million spent in 2012 – as Table 8.5 shows.[72] This creates a "huge gap" with an estimated $10 to $100 *billion* in annual funding needed

to prepare all developing countries for climate change.[73] Similarly, an assessment from the Potsdam Institute for Climate Impact Research, European Environment Agency, and other institutions calculated that at least $70 to $100 billion of investment will be needed per year for every year from 2010 to 2050 if adaptation needs are to be met.[74] As one recent independent evaluation put it, "the output of these funds falls far short of the estimated needs."[75]

Table 8.5 Multilateral adaptation funds disbursed (in millions of US dollars)

		2007			July 2012	
Fund	**Goal**	**Pledged**	**Received**	**Disbursed**	**Pledged**	**Dispersed**
Strategic Priority for Adaptation	Pilot projects that address local adaptation needs and generate global environmental benefits	50	28	14.8	–	50
Least Developed Countries Fund	Implementation of most urgent adaptation projects in LDCs, based on NAPAs	163.3	52.1	12	537	334
Special Climate Change Fund	Activities aimed at adaptation as well as three other purposes: technology transfer, economic diversification, and support in key sectors	70	53.3	6	240.68	162.24
Adaptation Fund*	Concrete adaptation projects in developing countries that are particularly vulnerable to the adverse effects of climate change	–	–	–	350	165
Total		283.3	133.4	32.8	1,127.68	711.24

*The Adaptation Fund was intended to be a three-year pilot program and expended all of its money by 2010.*Source*: Adapted from Global Environment Facility and Flam and Skjaerseth.

A final uncertainty relates to whether the LDCF will continue to exist in the face of the creation of a Green Climate Fund. During the Sixteenth Cancun Conference of the Parties (COP 16) in 2010, industrialized countries pledged to mobilize $100 billion per year by 2020 to address the climate change needs of emerging economies. At the center of this pledge is the Green Climate Fund (GCF), which has already raised $30 billion in "fast-track" financing from 2010 to 2012. If it reaches the $100 billion amount, the GCF will be equivalent to the cost of the entire four-year Marshall Plan to rebuild Europe after World War II.[76] With the creation of this fund, the LDCF has an unclear future. As one formal review of the LDCF put it, "it is recognized that what happens next to the LDCF depends to a large extent on the outcome of the negotiations on adaptation financing between parties to the UNFCCC."[77]

Convoluted structure

As well as its funding, critics have attacked the LDCF for having a convoluted management structure that has resulted in unnecessary delays for projects. Part of the reason is that the LDCF is administratively and legally "outside of the GEF Trust Fund."[78] This fundamental difference, however, means that the LDCF had to create an entirely separate management structure. During the Fourteenth Conference of the Parties (COP14) at Poznan, Poland, in 2008, some least developed countries "expressed their frustration" at this structure, at the speed with which projects were allocated funding, and at the "long and complicated" nature of implementing NAPAs.[79] Figure 8.5, for example, shows how complex a typical LDCF project cycle for the UNDP, one of ten implementing agencies, can become.

Though managers at the GEF have made various attempts to expedite the process and improve the efficacy of the LDCF, and not all delays in project implementation can be attributed to structural factors at the GEF, three independent evaluations suggest that problems still remain. The first, conducted by the UNDP in 2009, noted "justifiable dissatisfaction" among participants "concerning the lengthy time periods and complex procedures required to move from the NAPAs to concrete projects. In some cases, these have led to time lapses of several years before projects get off the ground."[80] That review noted, for example, that projects took an average of 471 days to begin due to "bottlenecks" and the "many stakeholders and consultations involved." It found that even the preparatory phase required "a lot of work" that ended up being "demanding" for country offices and cautioned that GEF requirements and project criteria were "complicated" and "poorly understood." It lastly noted that the co-financing requirement of the LDCF meant some countries did not have the resources needed to get projects commenced.[81] The second review, conducted by the Danish Ministry of Foreign Affairs in 2010, concluded that "in order for the LDCF to play a complementary role to the emerging other climate change financing mechanisms greater responsiveness and flexibility of procedures will have to be introduced to ensure

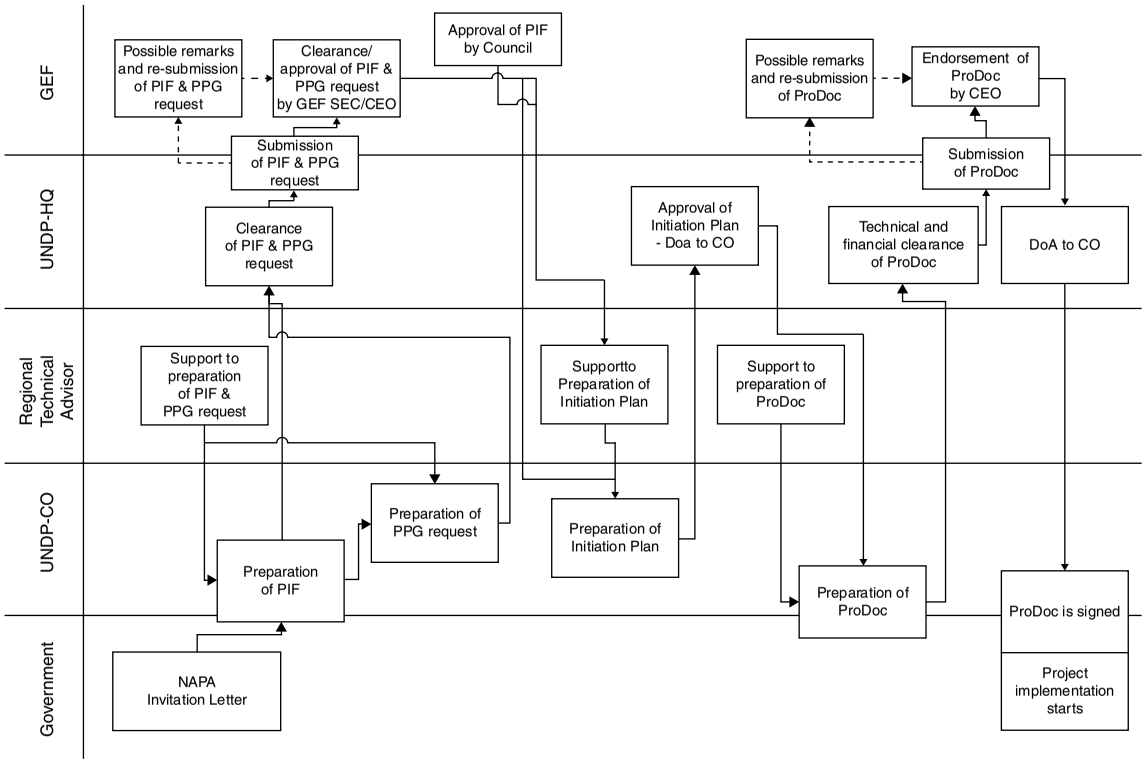

Figure 8.5 Process flowchart for a United Nations Development Program-Implemented Least Developed Countries Fund project

Source: United Nations Development Program.

lack of duplication and complementarity."[82] And the third review, from the nonprofit Climate Change Forum in 2010, criticized management structures at the LDCF that were "too complex," accused implementing agencies such as the World Bank as adding "further bureaucracy to the process," and concluded that "rules and structures make accessing funding difficult ... and time-consuming."[83]

In the LDCF's defense, managers have attempted to address many of these concerns in earnest. One recent 2012 evaluation from the Australian Government noted that many of these problems have been addressed. It praised the LDCF for "successfully working with fragile states that are also least developed countries to develop the national adaptation programs of action" and noted that the majority of projects "have made satisfactory progress towards their development objectives." It commented that human resources were well managed, that monitoring for the program was "strong," and that "the Evaluation Office has made commendable efforts to improve and facilitate professional evaluation work in the GEF and to provide leadership, within the GEF partnership and internationally."[84]

Moreover, during the Eighteenth Session of the Conference of Parties in Doha, Qatar, in late 2012, the UNFCCC Secretariat commented that the average size of LDCF projects had grown from $3.5 million to $5.3 million.[85] It also noted that "there is evidence to suggest that LDCs have been able to learn from their initial experiences of NAPA implementation, and to scale up successful approaches and practices. Thanks to a streamlined project cycle, user-friendly guidelines for accessing resources, and enhanced communication between the GEF Secretariat and LDC stakeholders, proposals are being developed and processed faster."[86] As one example, the approval times for NAPA projects decreased from an average of 32 months to 12 months, with some taking as little as 75 days, and elapsed time between project approval and CEO endorsement for the most recent projects has shrunk from 17 months to 14 months.[87]

The complexity of adaptation

Though the LDCF has made serious progress in implementing scores of adaptation projects, their sheer complexity has nonetheless proven beyond the means of the technical and institutional capacity of many implementing stakeholders. In Bhutan, for instance, draining glacial lakes has proceeded much more slowly than expected. Thorthormi Lake is so remote that the nearest potential helicopter landing site turned out to be more than 90 minutes away by foot. The unstable terrain made the use of heavy machinery like excavators impossible, and site-to-site transport ended up damaging equipment and scientific instruments. Boulders and silt made it difficult to measure how quickly ice was retreating, and created a safety hazard as drifting icebergs and strong winds made bathymetric surveys dangerous; some boats actually capsized and dumped scientists into the freezing water.

Unpredictable weather played a part as well, with snow blocking the path to the site eight months of the year and storms, such as Cyclone Aila, preventing necessary equipment from reaching Bhutan as scheduled.[88] Heavy rainfall in 2009 also washed away several key bridges to the site, delaying work by days. Because of its finances, the Bhutanese government was unable to purchase high-resolution satellite imagery, nor does it own a single helicopter which would aid in monitoring. Under these conditions, project managers could only afford to pay a few hundred local volunteers (shown in Figure 8.6) who had to use shovels, spades, and a few jackhammers and chisels; no automated or heavy machinery was available.[89] As a result work has progressed "at a snail's pace, much slower than we had hoped."

In the Maldives, the "heterogeneity" or "specificity" of which adaptation measures work with each island has led to complications. As one adaptation practitioner told the author:

> The unique geography of Maldivian islands is a challenge when it comes to infrastructure, even softer adaptive measures. The needs of an elongated island on an outer atoll will differ greatly from those of a roundish island on an inner atoll. Patterns of sedimentation, the type and longevity of coral reefs, the socio-demographic composition of settled communities will all require different, site-specific options. There is likely not a "one size fits all" solution.

Broadening beyond the four demonstration islands is "essential" to truly protect the Maldives, yet "accomplishing this task in reality could prove difficult." In Bangladesh, despite the government's training efforts, capacity-building efforts have proceeded "weakly" and "slowly," and in

Figure 8.6 Bhutanese volunteers draining Thorthormi Lake in 2010

Cambodia the average government officer still possesses minimal knowledge about climate change and therefore may not see the necessity for adaptation efforts.

Inability to eliminate risks

The centerpiece of the LDCF is the creation of country-specific NAPAs, which represent a critical first step in implementing adaptation projects. These NAPAs, while useful tools, are ultimately only guideposts for how to prioritize adaptation investments; they do not directly provide the financing for those plans. As one GEF analyst put it, "the success of the NAPA process will largely be determined by how well it paves the way for scaled up investments in climate-resilient development in accordance with integrated, long term plans."[90] In other words, the presence of such plans is no guarantee their recommended measures will be implemented. It's hard to fault such countries for this shortcoming (of having a plan but not following it) since one study of adaptation planning in the United States, Australia, and the United Kingdom confirmed that these countries do the same.[91]

Even if countries were to fully follow the recommendations embodied in their NAPAs, however, there is no guarantee they can sufficiently increase resilience or lower climate-related risks. Consider the case with rising sea levels. Data from the IPCC suggest that by 2100 we could see temperature changes of 8.66 degrees Fahrenheit (4.81 Celsius) and that already, in 2012, temperatures have changed 1.03 degrees Celsius from preindustrial times (see Figure 8.7). Consequently, Figure 8.8 predicts an almost certain 1-meter rise in sea level by 2100. Under the most severe of these projections, if the Greenland Ice Sheet melts, sea levels could rise a stark 6 meters – enough to inundate almost all low-lying island states as well as coastal areas from San Francisco and New York to Amsterdam and Tokyo. Once a farfetched scenario, the destabilization of ice shelves and the sudden and unexpected collapse of the West Antarctic ice sheet now have scientists predicting "even greater likelihood of sea level rise in key regions."[92] Concentrations of carbon dioxide in the atmosphere could exceed 1,000 parts per million by volume by the year 2050 if trends continue.[93] Another 2011 synthesis of the scientific literature concluded that "there is now little to no chance of maintaining the rise in global mean surface temperature at below 2°C," and that "extremely dangerous climate change" will most certainly be incompatible with human and economic "prosperity."[94]

If sea levels rise as predicted under these scenarios, practically no amount of adaptation or investment in resilience can "save" countries such as Bangladesh or the Maldives. As one Bangladeshi government official told the author:

> The challenge Bangladesh now faces is to cope with changes in climate already happening every year. We are strengthening coastal embankments,

> yes, but the intensity of erosion and frequency of storms are also increasing and I feel like we are often in a race against time where time is running out. We have developed saline-tolerant rice varieties but the concentration of salinity is going up. We can't keep on producing crops when land is flooded and water salty; it's practically not possible at the moment. Adaptation has its limits.

If the situation worsens, or if adaptation investments are not able to keep pace with vulnerabilities and risks, Bangladesh may have to switch to "retreat" measures such as forcibly relocating communities to higher ground.

Similarly, in the Maldives, such sea level rises would put the country "completely under water." Most islands are less than 1-meter high, meaning even small rises in sea level could subject the country to "regular tidal inundations."[97] These bleak and extreme projections may be why the Maldivian government is already relocating people to artificial islands, called

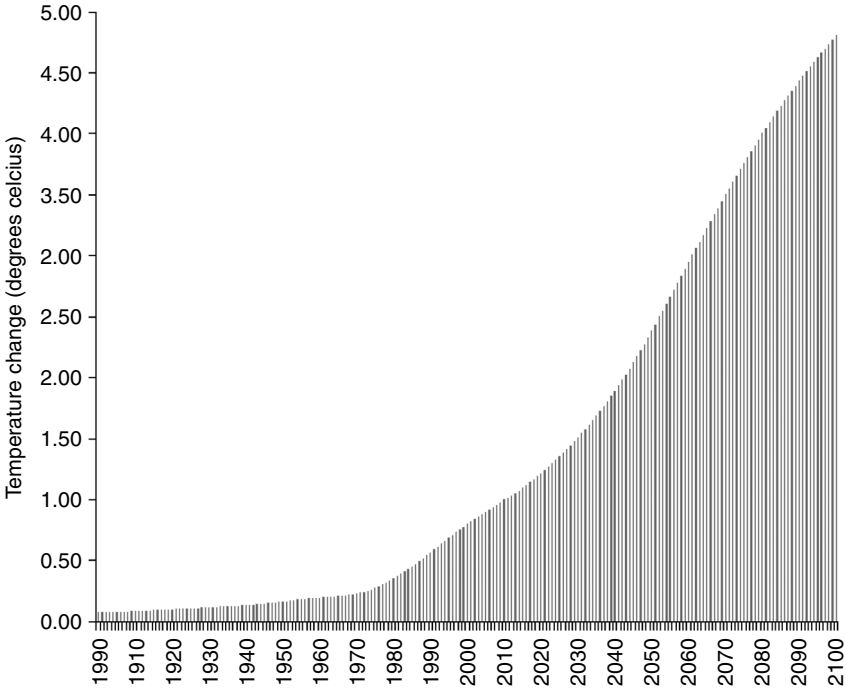

Figure 8.7 Expected global temperature change from preindustrial times (degrees C), 1900 to 2100[95]

Source: Adapted from International Energy Agency and Intergovernmental Panel on Climate Change.

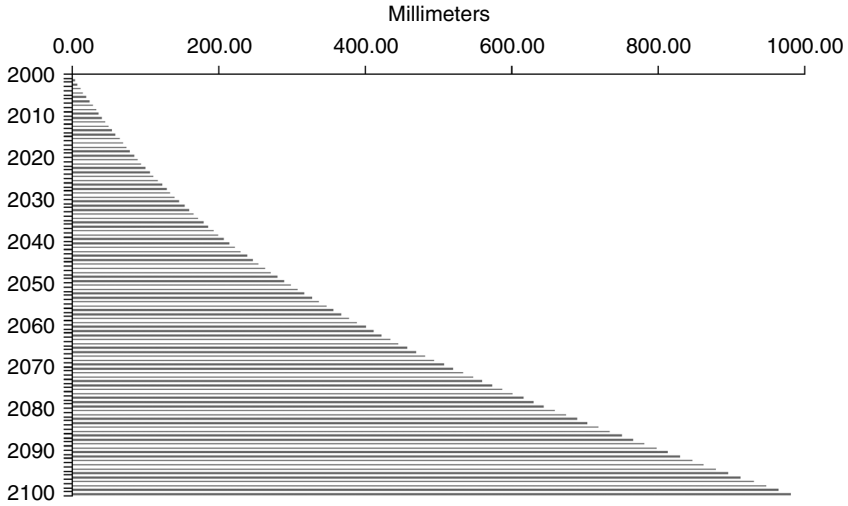

Figure 8.8 Expected sea level rise from 2000–2100 (mm)[96]

Source: Adapted from International Energy Agency and Intergovernmental Panel on Climate Change.

"designer islands." One such island, Hulhumalé in Malé Atoll, is set to house 100,000 people, many of them climate refugees, by 2030; construction is ongoing and it is currently home to 20,000 residents. The government also unveiled Dhuvaafaru Island in Raa Atoll in March 2009. Formerly an uninhabited forest, the entire island was raised and a new village built for the 4,000 survivors from Kandholhudhoo, an island destroyed by tsunami.

Conclusion: lessons and implications

The LDCF brings to light four salient conclusions.

First, it underscores the necessity of viewing resilience to climate change as multidimensional. As Table 8.6 summarizes, Bangladesh is not only sponsoring dykes and mangrove plantations, it is incentivizing agriculture and aquaculture to improve community income and training local officials. Bhutan is not only altering the physical shape of glacial lakes and rivers, building shelters, and creating an early warning system, but educating public and private leaders about emergency preparedness and climate risks. Cambodia is not only experimenting with crops and rehabilitating canals and ponds, but educating provincial officials and empowering local villagers to decide on infrastructure investments. Maldivian planners are not only thickening coastal vegetation and nourishing coral reefs, but decentralizing planning and disbursing funds directly to local communities so that they can decide what is best for them. Their efforts remind us that adaptation may

Table 8.6 Efforts in least developed Asian countries and their contributions to adaptation

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

work best not by improving technology alone, but by seamlessly strengthening three types of adaptation – infrastructural, organizational, and social – to bolster ecosystems, communities, and human organizations.

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

- Building responsive capacity, such as improving communication between institutions, or enhancing the mapping or weather monitoring capability of a government institution;
- Managing climate risks, such as disaster planning, researching drought resistant crops, or climate-proofing infrastructure;

- Confronting climate change, such as relocating communities or repositioning infrastructure in response to flooding or glacial melting.[98]

Similarly, the WRI, in collaboration with United Nations Development Program, United Nations Environment Program, and World Bank, argued that three dimensions to resilience exist and must be promoted synergistically. Ecological resilience refers to the disturbance an ecosystem can absorb without changing into a different structure or state. Disturbances can be natural, like a storm, or human-induced, such as deforestation. Social resilience refers to the ability of a society to face internal or external crises and still cohere as a community and possess a sense of identity and common purpose. Economic resilience refers to the ability of an economy to recover from shocks, and often entails having a diversified economy composed of members with a variety of different skills.[99]

However, multidimensional resilience also entails risks: degradation or destruction along one dimension of resilience can affect the others; the influence can be both positive and negative. Depleting a forest, for instance, could reduce ecological resilience, which in turn creates fewer jobs (affecting economic resilience) and erodes the community's social resilience (by causing a high proportion of migration or dissention within the community). Conversely, enhanced ecological resilience can improve rents and revenue from logging (economic resilience) and also improve business skills and connection with markets (social resilience). Resilience can be reactive, making the present system resistant to change, or proactive, creating one that is capable of adapting to change.[100] The key challenge for future adaptation efforts will be promoting different types of resilience – infrastructural, institutional, community – that do not trade off against each other, where improving one type is not to the detriment of the others.

Second, one of the striking attributes of the LDCF is its voluntary nature. The international community has mobilized more than $600 million for least developed countries, money they were under no real obligation to raise (other than a moral one, and a mandate from the Conference of the Parties of the UNFCCC), no small sum even if it's insufficient to fully implement all of the adaptation projects in need. And the LDCF has raised these funds relatively quickly in about a decade, and at a scale involving almost four dozen countries and hundreds of partnering institutions.[101] The LDCF does have its troubles related to uncertainty over funding and the complexity of adaptation projects in the context of LDCs, but given that it relies on goodwill it's amazing it works as well as it does.

Third, the LDCF affirms that investments in adaptation pay for themselves quickly, even when being implemented in the poorest countries on the planet. The sorts of adaptation measures being implemented under the LDCF have, according to the Asian Development Bank, a future return on investment as high as 40 to 1. Moreover, these investments in adaptation mitigate carbon

dioxide emissions 2 to 500 times more cheaply than alternatives, and they also leverage an additional $4.66 for every $1 committed. The point here is that the costs of inaction clearly outweigh the cost of adaptation.

Fourth, and lastly, this chapter and the LDCF's experience to date demonstrate the value of a functions-based approach to resilience and adaptive capacity rather than an asset-based one. Community or social assets – things like higher wages or better technology – are useless if communities do not have the skills or capacity to use them. Knowledge and assets must be coupled with capacity and improved governance. This creates a more fluid and messy picture of adaptation, but also one that is more realistic. Assets remain only potential until communities leverage them, and adaptation programs must find ways to improve living standards. Viewing adaptation in this way requires conceptualizing resilience not only as infrastructure and technology, but also as the broader social and economic forces that need to occur so that communities can use their assets to manage climate risks.