

Where warming hits hard

Threatened with encroaching seas, dwindling water supplies and fiercer storms, Bangladesh is already suffering the ill effects of rising global greenhouse gas emissions. **Mason Inman** reports on how the region is coping with climate change.

Ali Akbar Adi takes a break from steering his ox-driven plow across his small plot of land, digging furrows for a crop of lentils and beans. “When salt water comes in, the yields are very low,” he says.

Storm surges push this salty water up over the embankments around his field in the district of Bhola, an area that forms Bangladesh’s largest island and is situated the mouth of the vast Meghna river. “There are places to go, but we don’t feel as safe in them,” Adi says. “We feel protected here. But we’re afraid the embankment may break in the near future.”

For now, embankments like those protecting Adi’s field enclose much of Bangladesh’s coast, keeping out the tides and all but the worst storm surges. But for how long? Rising sea levels threaten to eat away at this embankment, just as

they did last year, ripping a huge breach in another dike a few hundred metres away.

As temperatures rise, creeping seas levels are just one of the threats that could wreak havoc on the region — often referred to as ground zero for climate change — and unravel its recent economic and social progress.

Covered deep with silt from crumbling Himalayan mountains, carried downstream by the Ganges and Brahmaputra and hundreds of smaller rivers that braid together across Bangladesh, this incredibly fertile land sprouts everywhere with green — rice stalks, palms, coconut trees and the vast swampy Sundarbans mangrove forest. The country now feeds itself, despite having almost 150 million mouths packed into an area the size of the US state of Iowa, giving it the world’s highest population density, outside of small island nations and city-states such as Singapore and Vatican City.

Although still poor, the country has left behind its earlier reputation as an “international basket case”, a term once unkindly bestowed on it by a US government official. Its economy is growing fast, the poverty rate is falling and the average lifespan has now stretched to 63 years.

NATURE’S LABORATORY

Nonetheless, nature is harsh on Bangladesh. “We are nature’s laboratory on disasters,” says Ainin Nishat of the International Union for Conservation of Nature (IUCN) in Dhaka, Bangladesh. “We don’t have volcanoes. But any other natural disaster you think of, we have it.” The rivers swell with summer monsoons, filling Bangladesh’s vast flood-plain and submerging a quarter to a third of the land in a typical year — and up to two-thirds in the worst of years. Several cyclones usually tear through the heart of the country each year, drowning people in storm surges and ripping up trees and homes. Less sudden calamities — droughts in the country’s few

highland areas, erosion of the river banks and coastlines — also rob people of food and land.

“We are nature’s laboratory on disasters. We don’t have volcanoes. But any other natural disaster you think of, we have it.”

Ainin Nishat

Climate change will almost certainly make these disasters worse, threatening to reverse the country’s progress. Hurricanes in this region have gotten stronger in recent decades¹, and continued warming in the Indian Ocean could see the trend continue, some researchers predict². Monsoon rainfall is likely to increase and to fall in more intense bursts³, making the annual floods broader, deeper and longer, and this could increase river erosion, too. Farmers are already reporting changes in the growing seasons. More erratic weather is making it hard for them to grow crops on the schedules that worked in the past. And then there’s the danger of the encroaching sea, which threatens to submerge a substantial part of the country, to worsen monsoon floods and to help storm surges clear protective embankments. “All of that combines to [make] a recipe for pretty horrific disaster,” says Atiq Rahman, executive director of the Bangladesh Centre for Advanced Studies (BCAS) in Dhaka and a lead author on the latest report of the Intergovernmental Panel on Climate Change (IPCC).

ENCROACHING OCEAN

Of all of the effects of climate change, sea level rise may pose the most pervasive challenge for Bangladesh. Nearly the entire country is a vast, flat delta, where even a modest climb in the height of the Bay of Bengal could push water deep inland if it weren’t for the protective barriers along the coast.



Halima Katun stands on top of a breached embankment in Bhola, Bangladesh, where her land was lost to erosion.

MASON INMAN

After being fairly stable for a couple of thousand years, sea levels have crept up about 20 centimetres since the mid-1800s. For the coming century, the 2007 IPCC report talks about sea level rise in centimetres — to be precise, 18 to 59 centimetres. But most climate scientists agree these estimates are too conservative, as they overlook the ways glaciers and ice sheets can slip, crack and calve off icebergs to dump increasing amounts of ice into the oceans. Now that researchers are watching this happen and beginning to understand these processes, known as glacial dynamics, some are predicting much larger increases in sea levels.

To get a rough upper limit on how far sea levels could rise, glaciologist Tad Pfeffer of the University of Colorado at Boulder and colleagues recently calculated the effects of all the world's glaciers and ice sheets flowing at very high but plausible speeds. By 2100, they figured, sea levels are likely to rise by 0.8 metres, and possibly as much as 2 metres⁴.

But climatologist James Hansen of the NASA Goddard Institute of Space Studies, for one, argues that more extreme changes could be in store. Hansen says it is possible that continuing to burn fossil fuels at current rates would raise sea level several metres by the end of the century⁵, because seas have risen several metres per century in the ancient past while being warmed less rapidly than the ocean is by man-made greenhouse gases today.

"We don't really have an upper limit [on sea level rise], but we can talk about it sensibly in terms of likely magnitudes," says Richard Alley, a glaciologist at Pennsylvania State University. "No one really believes we can destroy an ice sheet in mere decades — at least centuries would be required based on what we know about ice flow." But with Pfeffer's estimates, "you probably have enough information to calibrate your fear of flooding," says Alley.

What is certain is that even if people stopped emitting greenhouse gases in the next few decades, Bangladesh would still be committed to coping with sea level rise for centuries³. But continuing 'business as usual' could make the situation much worse as major ice sheets disintegrate.

GAINING GROUND

Considering elevation alone, even a one-metre rise would swallow about 15 to 20 per cent of Bangladesh's land area, where about 20 million people live today⁶. But such estimates can be misleading, since they leave out some crucial factors. For one thing, Bangladesh's delta is now

expanding, as sediments settle along the coast and create new land (Fig. 1).

"It's adding nearly 20 square kilometres a year in the coastal areas," says Maminul Haque Sarker, a morphologist at the Center for Environmental and Geographic Information Services (CEGIS) in Dhaka. His recent analysis⁷ of satellite images shows that Bangladesh has been gaining land for decades, and old maps from the early colonial era suggest the country has been growing this way for centuries, says Sarker. "There's a lot of accretion, and a lot of erosion, and they're almost in balance," he says. "We are gaining land — but it is a net loss." That's because the new land isn't of much use right away. For these coastal areas to support many people, they need embankments to protect them from tides and storm surges, and then they take decades to become productive, says Sarker.

Many estimates of the land area that would be lost to sea level rise are also misleading because they don't factor in the embankments that protect much of the coast, argues Nishat of IUCN. These embankments were built starting in the 1960s to keep high tides at bay, and they also blunt the force of storm surges.

They will hold back modest sea level rise, as long as they hold up — which is a major caveat. In many places, such as near Ali Akbar Adi's fields in Bhola, the embankments have crumbled under the onslaught of floods and storm surges.

Yet most experts here say the country's only option for saving the majority of coastal areas, both old and new, is to build more embankments — and taller and stronger ones. "Heavy government investment is needed for constructing coastal embankments," says Rezaul Karim Chowdhury of the Coastal Association for Social Transformation Trust (COAST), a local development organization. "This is the number one priority for us."

SURPLUS SALT

Some parts of the coast, though, can't be protected by dikes — such as the Sundarbans. This thick, deep green, tangled forest — which stretches across the border into India, forming the world's largest single tract of mangroves — isn't as photogenic or well known as tropical rain forests, but it is one of the world's great hotspots of biodiversity. Submerged regularly by the tides, the Sundarbans are key breeding grounds for fish and shrimp,

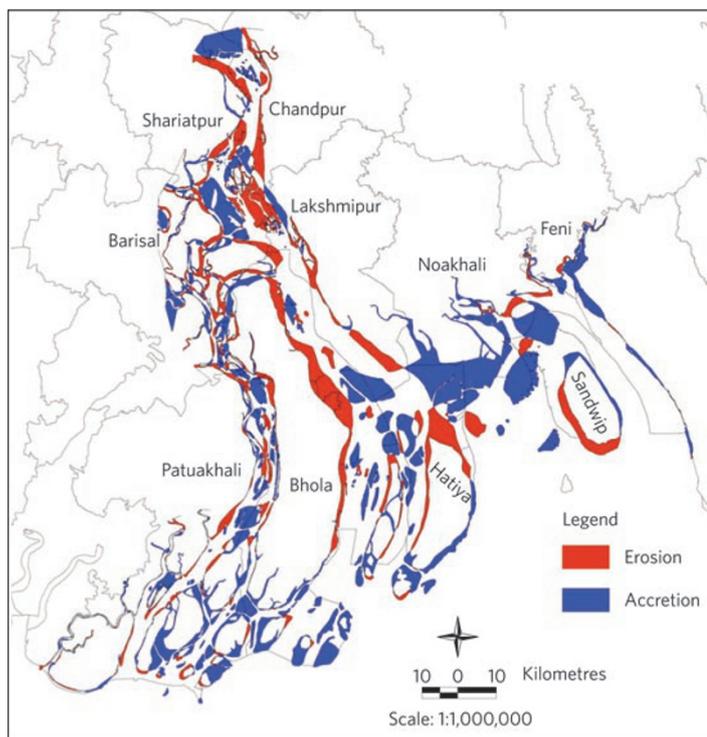


Figure 1 Erosion and accretion along the Bangladeshi coastline from 1973 to 2005. Courtesy of Maminul Haque Sarker and CEGIS.



MASON/INMAN

Looking glass trees, also known as Sundari trees, were toppled over by Cyclone Sidr, which tore through the region in November 2007.

and a refuge for the last few hundred remaining wild Bengal tigers.

These mangroves survive only in a slightly salty zone, where there's a delicate balance between encroachment of the saline tides and fresh water flowing down through the forest's rivers. The forest's most common species, the looking-glass tree (*Heritiera littoralis*), is highly sensitive to increasing salt levels. "With a 1 metre rise in sea level, the Sundarbans are likely to disappear, which may spell the demise of the tiger and other wildlife," said the IPCC in its 2001 assessment report³.

The forest is getting saltier, apparently in part owing to rising seas pushing deeper into the forest during high tide. However, for now the main culprit is the Ganges's dwindling flow as India siphons off more water upstream. The Gorai river, the main tributary feeding the Sundarbans, "used to flow during the entire dry season," says coastal morphologist Zahir-ul Haque Khan of the Institute of Water Modelling in Dhaka. "Now it runs dry in the winter."

"Of the increase in salinity — maybe 15, 20, 30 percent is caused by climate change," says Mahbubur Rahman, head of the Water Resources Planning Division at the Institute of Water Modelling. "It's very hard to tell." But the changes so far give an inkling of what's to come. The dry season will get drier, reducing flows even more, according to Ahsan Uddin Ahmed, Executive Director of the Center

for Global Change in Dhaka. This will allow rising seas to penetrate deeper into the forest during high tide. Even at the forest station in Karamjal, 60 kilometres upstream from the coast, deputy forest ranger Abdul Rob points out many of the mangroves are dying at their crowns and are becoming susceptible to fungal and viral infections.

The increasing saltiness of the water is believed to be behind these changes and is even undercutting people's livelihoods. "Sometimes when we plant crops, after 10 or 15 days, if there is no growth we pull up the plants and see there is no growth of the roots," says Santosh Kumar Gain, of Jaymonirgol, a small village in Bangladesh's southwestern coastal region. "We are really tired of this," Gain says.

It's already too salty for traditional crops, this region's residents say. "This area was all [rice] paddy before. Now, no paddy," says Matthew Digbijoy Nath of Choli, another village near the southwestern coast. "The trees look nice, but the coconut trees — there are no coconuts on them." Saltwater intrusion also threatens the fish farms that dot the land here, he adds. "If it gets more salty here, this population will not be able to live here. No paddy, no fish. How will people live?"

EIGHT OR FLIGHT

The problems facing people in this district are typical of what's to come for

the coast. "Even if there is a small sea-level rise, the brackish water zone would increase, so there would be a big impact in terms of salinity rise," says Nishat of the IUCN. "If people have to leave, it will be because of food security, not because they're underwater."

But if Nath and his family leave the area, should they be considered 'climate change refugees'? Their problems seem to be partly due to sea level rise, but so far the bigger impact is the dwindling flow from upstream. As well as the flow being restricted from the damming of rivers in India, scientists say that high-elevation Himalayan glaciers, which provide up to half of the dry-season flow for the Ganges and Brahmaputra Rivers, are now thinning and threatening the supply of fresh water to the region⁸. These impacts are predicted to get much worse, and there's little doubt that the future could see many climate change refugees — perhaps tens of millions — fleeing parts of Bangladesh. Already, climate change is having enough of an impact here that it's partly responsible for pushing some people off their land, says Rahman of BCAS: "I believe there are climate change refugees already."

A few small-scale projects run by aid agencies and other organizations have set out to help people cope with the impacts of climate change. In the coastal areas, these include growing a salt-tolerant variety of rice and catching rain to use as salt-free drinking water. However, such projects have reached only small numbers of people, and Chowdhury of COAST argues they will make "very little" difference in the future. Chowdhury and others support large, concerted efforts to help people here adapt, for example by building embankments. The main barrier to such projects is lack of money. "With its own resources, Bangladesh will not be able to cope," Chowdhury says. But Bangladeshis have not caused these problems, he argues, since their greenhouse gas emissions per person are about one-hundredth of the average American's⁹. "We are demanding compensation and reparations."

Lutfun Naher Azad of the Socio-economic Development Programme, another local development organization in the coastal district of Noakhali, also supports such reparations — as long as they're used wisely. "It would be bad if you gave money directly to the suffering people, because it will not help," she says. "The money should be spent for building embankments," and other large-scale projects in building stronger homes and

educating people on the effects of climate change and how they can adapt.

Some large-scale funds are already in the works to help developing countries adapt. Setting up one such source, called the Adaptation Fund, was a key part of the latest round of UN talks on climate change, held in Poznan, Poland, in December. It has amassed US\$80 million so far and could start paying out this year, but developing countries say this is only a fraction of the billions of dollars per year that is needed. So far, the only funds received by Bangladesh and other developing countries have financed 'national adaptation plans of action'. Bangladesh completed theirs in 2005, and in September they issued a second-generation adaptation plan¹⁰ laying out the tasks ahead.

The country has made big strides in coping with disasters, mainly through large projects funded by foreign aid. In past decades, for example, cyclones tore through the region, the worst killing hundreds of thousands of people. But when the category-5 Cyclone Sidr struck in 2007, the death toll was around 3,500, and the lives saved were credited largely to embankments, cyclone shelters and warning systems that protected many of the poor.

COLOSSAL CHALLENGE

In discussing what Bangladesh can do in the future, many here think that instead of abandoning lands to the waves,

they should follow the example of the Netherlands and fight the tides for as long as they can. "What do you do, if the sea level goes up by 1.5 metres?" asks Nishat of the IUCN. "You build dikes, like the Netherlands has done."

"With its own resources, Bangladesh will not be able to cope. We are demanding compensation and reparations."

Rezaul Karim Chowdhury

"What we need is to strengthen the embankments to withstand stronger storm surges, and to raise them significantly in some areas," says Rahman of the Institute of Water Modelling. "We need to have a concerted effort on this. They were designed without considering climate change, and need to be redesigned."

Following the Netherlands' approach will be a colossal challenge, though, as several hundred kilometres of Bangladesh's coast would need dikes higher and stronger than any built before. Some think it is a fool's errand. "This is not the Netherlands," says Atiq Rahman of the BCAS. "The cost for saving the coastal areas is phenomenal — and you can do only bits. This is not something, I think, that is within human capacity."

How long Bangladesh will manage to cope, and how successful it will be, depends in large part on how much adaptation funding richer countries supply and how deeply those countries cut their greenhouse gas emissions. But it's clear that Bangladeshis, as they have for decades, want to continue their fight with the sea.

Published online: 15 January 2009

doi:10.1038/climate.2009.3

References

1. Elsner, J., Kossin, J. P. & Jagger, T. H. *Nature* **445**, 92–95 (2008).
2. Rao, B. *et al. Geophys. Res. Lett.* **35**, L15710 (2008).
3. IPCC. *Climate Change 2007: Impacts, Adaptation and Vulnerability* (eds Parry, M. L., Canziani, O. F., Palutikof, J. P., van der Linden, P. J. & Hanson, C. E.) 23–78, 317, 556 (Cambridge University Press, Cambridge, UK, 2007).
4. Pfeffer, W. T., Harper, J. T. & O'Neel, S. *Science* **321**, 1340–1343 (2008).
5. Hansen, J. E. *Environ. Res. Lett.* **2**, 024002, doi:10.1088/1748-9326/2/2/024002 (2007).
6. *Bangladesh: Climate Change and Sustainable Development*. Report No. 21104-BD, 12 (World Bank, Rural Development Unit, South Asia Region, Dhaka, Bangladesh, 2000).
7. Dummett, M. *BBC News* 30 July 2008; http://news.bbc.co.uk/2/hi/south_asia/7532949.stm
8. Kehrwald, N. K. *et al. Geophys. Res. Lett.* **35**, L22503 (2008).
9. United Nations Development Programme. *2007/2008 Human Development Report: Bangladesh*; http://hdrstats.undp.org/countries/country_fact_sheets/cty_fs_BGD.html
10. Gilbert, N. *Nature News* 11 September 2008; <http://www.nature.com/news/2008/080911/full/news.2008.1103.html>

Mason Inman is a science and environmental journalist now based in Pakistan. His travel in Bangladesh was supported by a Middlebury Fellowship in Environmental Journalism.