Working with water

Nations threatened by sea level rise are starting to look at how they can work with nature to defend their coastlines. **Mason Inman** reports.

No place has done battle with the sea like the Netherlands has. Since the 1400s, the nation has built dikes to protect against tides and storm surges, and has pushed out into the ocean, creating new land. Over the past century, in particular, the Dutch have fought back against storm surges blowing in from the North Sea by 'hardening' their coastline, constructing dikes covered in concrete and rock, and metal barriers that can close off deltas and estuaries.

But despite the stalwart efforts at fortification, these hard defences are under threat. Today about a quarter of the country is below the current sea level, and more than half is flood prone. In recent decades, funding for maintaining dikes and other defences has fallen, and in a 2006 audit, at least one-quarter of these structures weren't up to the Netherlands' own standards, enshrined in law[1]. Faced with the reality that sea levels will continue to rise for the rest of the century — probably as least as fast as they are climbing now (see page 42) — the Netherlands has been forced to rethink its strategy and is now pioneering a soft approach to self-defence.

The concept — called 'ecological engineering' — encompasses a variety of approaches for working with nature rather than confronting nature's forces head on. Researchers hope these techniques, including the restoration of wetlands, beaches and natural floodplains, could help deltas and coastal areas adapt to rising seas and fiercer storms.

The Netherlands converted to the idea of ecological engineering at the recommendation of the Delta Committee, a panel that, in 2008, developed guidelines for keeping the country dry as sea levels rise. "We have chosen, after many, many debates, to soften the idea about how to protect the Dutch coast," says Pavel Kabat of Wageningen University in the Netherlands, a member of the panel. With this switch, the committee has "changed the philosophy completely", he says.

Ecological engineering approaches are often cheaper than fortifying coastlines with concrete walls or defending cities with ever-stronger levees, advocates say. And in the long run, they could be more effective. A similar philosophy is now being adopted in parts of the United States and Asia, and if its proponents are right, ecological engineering could become one of the main tools for adapting to rising seas. "With sea level rise, it's not going to be possible for us to do engineering as usual," says William Mitsch of The Ohio State University in Columbus. "It will be too much to try to fight head on, with hard defences to protect all the settled coasts." Ecological approaches, he says, are "more about adapting to what's happening, rather than fighting it".

RUN RIVER RUN

After the calamity of Hurricane Katrina in 2005, many favoured protecting Louisiana with harder defences. According to Mitsch, who is consulting for the state on their plans for the delta, some talked of "ringing Louisiana with dikes to protect it from storm surges, and making it like the Netherlands". As in the Netherlands, this would be hugely expensive. It would also be an ecological nightmare, say several experts on coastal ecosystems. Mitsch says, "It would absolutely destroy the estuary", which supports the Gulf of Mexico fishery.

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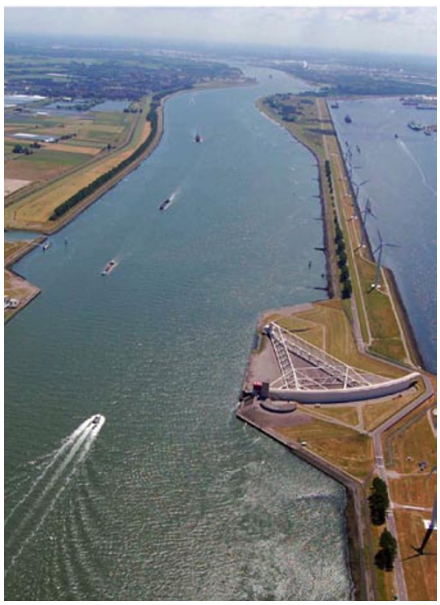
The Mississippi delta is already sinking about 5 millimetres a year on average, with some parts sinking faster. Add to that average global sea level rising by about 3 millimetres a year, and local sea level rise in Louisiana can be as high as 25 millimetres a year, among the fastest in the world[2]. The roots of the problem go back at least 150 years, to when residents began building levees along the Mississippi River's banks to keep it from spilling over and flooding nearby land. Later, they started draining the swamps around the city of New Orleans, opening new areas to development. In doing so, they cut the land off from the river's muddy waters, which are rich in sediments that could build the delta back up. Now the delta's wetlands, which help soak up excess water during storms, are vanishing rapidly, and Louisiana's levees must work even harder to keep the water out.

Louisiana is faced with sea level rise "on a monumental scale", says Mitsch. That means that for the city of New Orleans to survive, it has no choice but to fortify itself against rising sea levels and floods. "The city needs to be protected, just by the fact of where it is," he says. But in ecological engineering, Mitsch and other experts see a better way forward for Louisiana. Though, according to Mitsch, leaders in the region are on the fence right now about which path to take, a recent federal initiative could help tip the balance in favour of



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The Netherlands has traditionally defended itself against the sea with concrete and metal structures, such as the storm-surge barrier Maeslantkering, near Rotterdam.

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the softer approach. In early March, the Obama administration issued a roadmap for restoring the Mississippi delta that throws the weight of the US government behind efforts to re-establish wetlands. Created under the White House Council on Environmental Quality and the Office of Management and Budget, along with a slew of other federal agencies, the roadmap argues that "unless we stem the rapid rate of ecosystem loss in the region, the ecosystems and the services they provide will collapse"[3].

If this approach works in Louisiana — and other places that face similar problems — then wetlands restoration could become a key tool for protecting coastlines from storms and rising seas for decades to come. "The same thing is going to happen to more and more places," says Rusty Feagin, a coastal ecologist at Texas A&M University in College Station. For many people living on deltas around the world, the way this state copes with rising seas could be a test case to learn from.

Right now, "they're actually building wetlands by dredging and pumping sediments to build the land back up", says coastal ecologist John Day Jr of Louisiana State University in Baton Rouge. But this approach is expensive, says Day, who estimates it costs around $30,000–$50,000 an acre. Moreover, dredging and pumping sediments works only on a relatively small scale. Another method that could have an impact on large areas is to let the water back in by opening up some of the levees protecting farmland and other areas where few people live. If rivers were allowed to run back over former floodplains, these lands, fed by river water and sediments, could become wetlands again. "River diversions are the only viable thing I've seen down there that have even a possibility of being on the right scale," says Mitsch.

On river diversions, "the Mississippi work is leading the way", Day says. But existing projects involve flows only about one-hundredth of what the floodplains received before the levees went up, he adds, so much more river water eventually needs diverting. The Obama administration's roadmap makes the same case, arguing that the projects already planned or underway are not intended to restore the wetlands, but are providing flood control "to prevent damage beyond a 'point of no return' so that future projects ... will have a better chance of success".

BUILDING BUFFERS

Like Louisiana, the Netherlands could also benefit by letting the water in. But when the Delta Committee presented some of their countrymen with this idea, it was seen as a rather bold proposal. Their suggestion was to allow occasional flooding on farms that are situated on tracts of peatland and protected by dikes. Without these defences, the land would be five to six metres below today's sea level, as deep underwater as the floor of an Olympic high-dive pool. Low in productivity, these farms are heavily subsidized by the European Union and are routinely pumped to prevent waterlogging, a job the country's iconic windmills did for centuries. But pumping the land is expensive, as is maintaining the dikes, and the cost will only climb upwards as sea levels rise.

This has raised the question of how sustainable it is to keep these areas dry. The Delta Committee recommended they could be put to better use in helping to protect other, more valuable land. When there's especially high flooding, these areas could take on some of the excess water, easing the burden on the country's dikes and preventing floods in other parts of the country. Kabat and his colleagues told local officials, "We may need, occasionally, to flood your land. When we said that, they were completely shocked," he recalls. "Some of these people lived through the flood of 1953", the most destructive in the Netherlands' modern history, says Kabat. After that disaster, the country started a huge program to strengthen and raise the dikes. "Now we're telling them they have to abandon this land. It's hard to accept."

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In Mississippi and in the Netherlands, coastal planners are proposing occasional flooding of farmland as a way of alleviating the pressure on dikes and protecting more valuable or densely populated land.

Rather than simply asking people to abandon their land, though, Kabat says there are more creative ways of trying to make the change. If the farms were allowed to flood occasionally, they would turn from grassland to a somewhat marshy area. Then instead of being a source of heat-trapping gases, the land would become a net sink of carbon dioxide as new plants grow[4]. For the carbon absorbed, the farmers could sell credits through the European Greenhouse Gas Emission Trading System. If carbon credits sell for at least €20 to €35 per tonne of carbon dioxide, the farmers could make as much from the carbon trade as they do now from farming, according to Kabat.

Another approach being considered by the Delta Committee is 'building with nature', or beach nourishment, in which sand is pulled from the sea floor and spread along the coast. Currently, the Netherlands is using some 15 to 20 million cubic metres of sand to just to keep the coastline static, Kabat says. With gradual nourishing, dune grasses and other plants would be able to colonize the beaches, strengthening them against storms and waves. An extra ten per cent in financing, the Delta Committee has estimated, would pay for enough beach nourishment to gradually build an extra kilometre or two of coastline over the coming century as an added buffer. If the Netherlands goes ahead with this strategy, the plan would be the first of its kind, says Richard Klein, a geographer and adaptation expert at the Stockholm Environment Institute. "It would certainly be the first time that natural coastal processes would be used to protect urban areas," he says.

CATCHING ON

It's not just well-off countries that are looking to restore their coastlines as a way of protecting against rising seas. In the aftermath of the tsunami that hit southeast Asia in late 2004, it became evident that some coastal regions had suffered less damage than others. In many deltas, native mangrove forests had been chopped down for firewood, or to make way for shrimp farms or other development. Others were

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lucky, it seems, to have left their mangroves intact. Although experts disagree on the extent to which the mangroves helped buffer the impact of the tsunami, Klein believes their effect was considerable. "Where the mangroves had not been cut, the land behind them was much [better] protected from the tsunami," he says.

"Some people talk as if we could get rid of hard defences and live in harmony with nature, but how much ecological engineering can accomplish is still a research and development question."
Robert Nicholls

Since 2004, several conservation groups — including Wetlands International, the World Wildlife Fund and the International Union for the Conservation of Nature — have established a 'Green Coast' project that helps coastal communities restore their mangroves to gain resilience in the face of storms, which will push further inland as seas rise higher. The scheme gives local people a financial incentive to help plant mangroves and to look after the seedlings, and so far it has reported a high rate of success, with more than 80 per cent of the trees surviving[5]. Green Coast was started first in Aceh, Indonesia — one of the areas hardest hit by the tsunami — and similar projects are now kicking off elsewhere in Asia and in several West African countries facing coastal erosion and sea level rise.

But not everyone is convinced that ecological engineering will live up to its proponents' claims. The problem, says coastal engineer Robert Nicholls of the University of Southampton, UK, is that there are few data on how much ecological engineering might help — or how much it might cost. "Some people talk as if we could get rid of hard defences and live in harmony with nature", he says, but how much ecological engineering can accomplish "is still a research and development question". Stephen Baig, head of the US National Hurricane Center's storm surge unit until his retirement in 2008, takes an even dimmer view. Although wetlands have many benefits, such as supporting fisheries, he says, they are "functionally useless as storm-surge dissipaters".

Even the supporters of ecological engineering realize that it can go only so far in staving off the damage caused by rising seas. "You can work with nature all you want," says Klein, "but it's all academic if we lose Greenland." For now, though, the softer approaches of ecological engineering are catching on, says Nicholls. "All of coastal engineering is moving in that direction, with people nourishing beaches instead of armouring coasts."

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