38. Ecological engineering in coastal protection

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Bangladesh is suffering from the effects of sea storms more than any other country on Earth and the threats from sea-level rises are daunting. In the delta formed by the confluence of the Ganges, Brahmaputra and Meghna Rivers, these threats are mitigated by one of the largest and lushest mangroves in the world, called the Sundarbans, an UNESCO World Heritage site. The Sundarbans are “so thick that history has hardly ever found the way in”, writes Salman Rushdie in *Midnight's Children*. History may soon find its way *against* the Sundarbans: there are advanced plans for building a large coal-fired power plant less than 15 km from the forest; both pollution and traffic of ships bringing coal from India would upset the fragile ecological balance there. In June 2019, UNESCO has declared the Sundarbans “World Heritage in Danger”. Yet another blunder in coastal protection?

In many places all around the world, the game is over; mangroves are gone. Consider, for example, Central America's Pacific Coast. There mangroves are indeed mostly gone; beaches, fields, roads, homes and finally people have followed suit. Even the very industrial shrimp farms that displaced mangroves now come under threat. In Africa, Nigeria has the largest mangrove ecosystem, the third largest worldwide. It protects the country's vast coastal areas against the increasingly damaging intrusions from the Atlantic Ocean; it also provides essential biological resources to millions of mostly poor people. Yet, large tracts among the most valuable ones in the Niger Delta have been lost to unbridled oil exploration and extraction. These losses are no exceptions. According to the United Nations Environmental Programme report on the state of mangroves worldwide (UNEP, 2014): “The deforestation of the planet's mangroves is exceeding average forest loss by a rate of three to five times, resulting in damages of up to \$42 billion annually and exposing ecosystems and coastal habitats to an increased risk of devastation from climate change” (UN News, 2014).

Of particularly high value for a country made up of more than 18 000 islands (6000 without permanent residents), mangrove forests have been severely depleted along Indonesian coastlines. The district of Probolinggo, East Java,

had mangrove-lined beaches, of which only a few patches remained at the beginning of this century. Amat Samsuri, a resident in a coastal village of the district, had been familiar with mangroves since childhood. He had noticed that where the mangrove was still in place, so were fishes and shrimps – which had almost completely disappeared elsewhere – and sediments were trapped by the remaining trees – on the other hand, erosion was severe elsewhere. He started replanting, progressively identifying favorable density and mix of plants, and recognizing the importance of maintenance during the first two or three years of growth.

After ten years of solitary work – but for a brother's occasional help – he was able to gather a team of voluntary coworkers, secure some support from local authorities, and finally the recognition and the support of Mangroves for the Future (MFF). From its creation in 2007 as a joint venture between the International Union for Conservation of Nature (IUCN) and the United Nations Development Programme (UNDP), MFF has supported – with money, technical and managerial assistance – about 400 projects in South and Southeast Asia, aiming at coastal ecosystems restoration and resilience building; in line with the Stockholm Resilience Centre, they see resilience as preparedness in the face of complex, changing and only partially known circumstances, on the basis of both local knowledge and applications of fast-developing applied ecological science (Lewis, 2005; Románach et al., 2018).

Mangroves and other coastal forests, marshes, coral and oyster reefs, are ecosystems that, in addition to a variety of ecological services they provide (Donato et al., 2011; Gittman et al., 2016), are partners in the protection of coasts. By dissipating at least part of the energy carried by the waves, they reduce the constant erosion of the coast and, in rough weather, the force of the impacts of a storm either on natural structures or on artificial protection barriers. In the Netherlands, where huge artificial structures are essential for protecting the polders that lie beneath sea level, mangroves, marshes and shellfish beds are now engineered in front of these structures. They also trap sediments: as they slow down the water, sediments settle. Sedimental accretion in mangrove forests more or less keeps pace with sea-level rises. Oyster reefs have the additional advantage of growing biologically. According to Harold van Waveren, chair of the Crisis Management Group at the Rijkswaterstaat (Directorate-General for Public Works and Water Management):

We can't just keep building higher levees, because we will end up living behind 10-meter walls... Protection against climate change is only as strong as the weakest link in the chain, and the chain in our case includes not just the big gates and dams at the sea but a whole philosophy of spatial planning, crisis management, children's education, online apps and public spaces. (Kimmerman, 2017)

That philosophy of building with nature and of deep social involvement is at the core of the renewed 2008 Delta Programme of protection against the sea (see the Deltares web page). Ecological engineering and the famed Dutch civil engineering go hand in hand, with salt marshes along the Waddenzee coastline in the north of the country; willow mangroves in front of the Dordrecht dykes – a link in the infrastructures protecting Rotterdam; and shell beds in the Oosterschelde coastal bay in the south of the country. And, as Ayana Elizabeth Johnson shows in Johnson (2019), New York City seems intent on going the Dutch way.

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