

# Chapter 1: Degradation of marine ecosystems

The extent of the benefits that communities and economies derive from the ocean depends on the overall health of the ocean. While some components of the marine ecosystem and the services they provide are more visible, such as fisheries, others are hidden below the surface. In this chapter, we conduct a closer examination of mangroves, seagrass meadows and coral reefs, among the most undervalued elements of the marine environment. Their degradation and the resulting adverse impact on marine life have been well documented,<sup>1,2</sup> but only in recent years has there been a more widespread recognition of their value.

Mangroves occur across 188 countries, but 75% of mangrove forests are found in just 15 countries. The Indian Ocean Rim countries are home to 20% of these,<sup>3</sup> translating to roughly 40,000 sq km.<sup>4</sup> Coral reef area is estimated at close to 69,000 sq km, around 30% of the global total.

Data on seagrass coverage in the Indian Ocean are scarce. This is indicative of the broader sentiment, explains Blandina Lugendo, lecturer in the department of aquatic sciences and fisheries at University of Dar es Salaam. “We are seeing greater awareness around mangroves and corals, but less so with seagrass meadows. Most people don’t know why we need to conserve seagrasses. It is the ‘silent’ habitat, often forgotten.”

In the Indian Ocean Rim, South-east Asia is especially rich in mangroves, corals and seagrass meadows. It is said to have the highest levels of coral biodiversity,<sup>5</sup> followed by the northern Mozambique Channel. In the western Indian Ocean, coral cover is the highest in Madagascar, Tanzania, Mozambique and the Seychelles,<sup>6</sup> whereas mangrove forests are mainly concentrated in Mozambique, Madagascar, Tanzania and Kenya.<sup>7</sup>

So far, conversations on these three habitats have mostly treated them in isolation but joined-up management would be more effective. “There’s limited understanding of the linkages among the three,” says Dominic Wodehouse, adviser at the Mangrove Action Project. “The system works much better if all three are healthy.” Seagrass beds are better protected against strong waves if coral reefs are present and mangroves prevent harmful sedimentation from land from reaching seagrass meadows and coral reefs. Many species, including snapper and spiny lobster, depend on multiple habitats through the

The Indian Ocean is home to:



20% of the world's mangroves

30% of the world's coral reefs



1 FAO, A review of mangrove and seagrass ecosystems and their linkage to fisheries and fisheries management, <http://www.fao.org/docrep/018/i3355e/i3355e00.htm>  
 2 S S Romañach et al, Conservation and restoration of mangroves: Global status, perspectives, and prognosis, 2018, *Ocean & Coastal Management*, <https://www.sciencedirect.com/science/article/pii/S0964569117301710>

3 UN Environment, 2018. Ocean and Habitat Atlas.

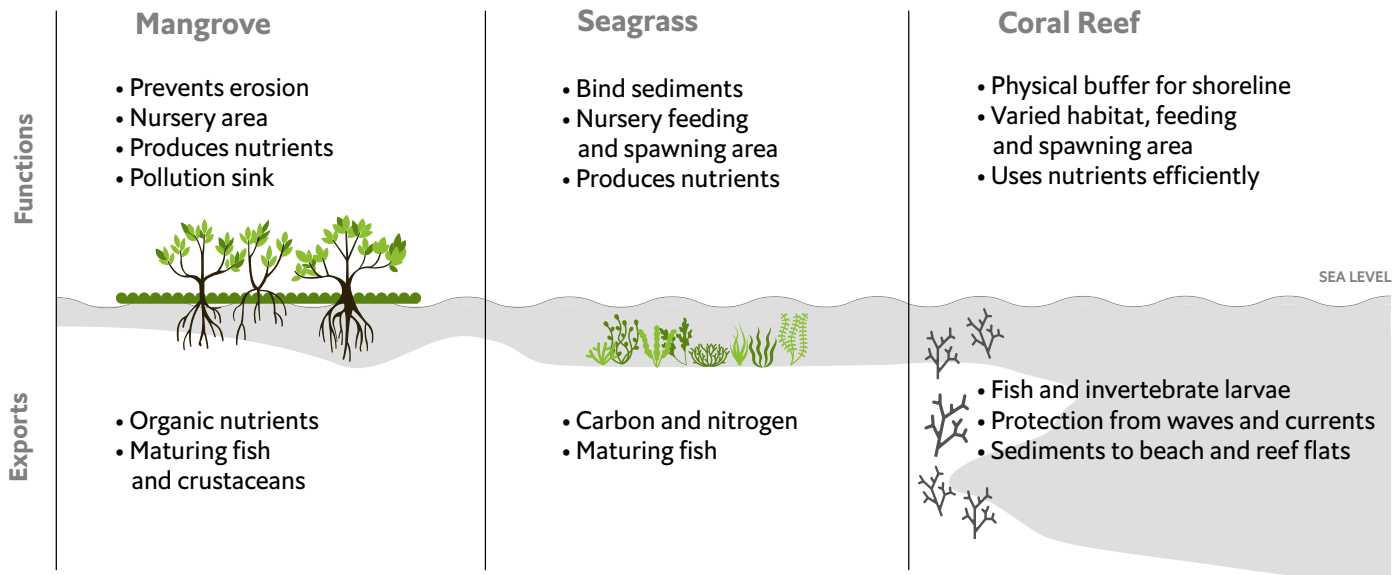
4 <https://www.ncbi.nlm.nih.gov/pubmed/21297949>

5 World Resources Institute, Reefs at Risk in Southeast Asia, [http://wriorg.s3.amazonaws.com/s3fs-public/pdf/rrseasia\\_full.pdf](http://wriorg.s3.amazonaws.com/s3fs-public/pdf/rrseasia_full.pdf)

6 Coral reef status report for the Western Indian Ocean, <https://drive.google.com/file/d/1PkHG7-xSixodgvnbgYMoZjLjkQs2-.8p/view>

7 Mangroves of the Western Indian Ocean: Status and Management, [https://www.researchgate.net/publication/311399453\\_Mangroves\\_of\\_the\\_Western\\_Indian\\_Ocean\\_Status\\_and\\_Management](https://www.researchgate.net/publication/311399453_Mangroves_of_the_Western_Indian_Ocean_Status_and_Management)

## A coastal ecosystem



Source: A T White, 2001, Philippine coral reefs: A natural history guide, 2nd ed. Bookmark Inc and Sulu Fund for Marine Conservation Foundation, Inc.

various stages of their life cycles, explains John Burt, associate professor of biology at New York University Abu Dhabi. “They use seagrasses as juveniles and coral reefs as adults. They migrate between habitats over the course of their lifetime.”

Together these habitats provide a variety of ecosystem services: they are breeding grounds for marine species and protect the coast from erosion. Mangroves are recorded as being the most effective in preventing coastal erosion, however, seagrasses and corals also play a vital role in diminishing wave size and power.<sup>8</sup> In addition, mangroves and seagrasses are vital for carbon sequestration—around the world they occupy only 0.5% and 1.1% of the total coastal ocean area but are responsible for 14% and 10%, respectively, of carbon sequestration in the world’s oceans.<sup>9</sup> The value of ecosystem services—including fisheries,

tourism and coastal protection—is estimated at US\$57,000 per ha per year on average,<sup>10</sup> equating to roughly US\$228bn across the Indian Ocean.<sup>11</sup>

### Degradation over decades

Given their proximity to land, these habitats are exposed to a variety of human activities and have suffered irreparable damage as a result. Their decline can be attributed to multiple sources including urban development and tourism; overexploitation by fisheries; agricultural and aquaculture conversions; and climate change.

Closer to land, mangroves are cut down to build beach-front hotels and residential properties as well as for infrastructure development. Seagrasses and coral reefs, further offshore,

8 G Guannel, et al, The Power of Three: Coral Reefs, Seagrasses and Mangroves Protect Coastal Regions and Increase Their Resilience, 2016, *PLoS One*, doi:10.1371/journal.pone.0158094

9 D M Alongi, Carbon sequestration in mangrove forests, [https://www.researchgate.net/profile/Daniel\\_Alongi2/publication/274116107\\_Carbon\\_sequestration\\_in\\_mangrove\\_forests/links/556b926408aec22683037b84/Carbon-sequestration-in-mangrove-forests.pdf](https://www.researchgate.net/profile/Daniel_Alongi2/publication/274116107_Carbon_sequestration_in_mangrove_forests/links/556b926408aec22683037b84/Carbon-sequestration-in-mangrove-forests.pdf)

10 WWF, Reviving the Ocean Economy, [http://d2ouvy59p0dg6k.cloudfront.net/downloads/reviving\\_ocean\\_economy\\_report\\_low\\_res.pdf](http://d2ouvy59p0dg6k.cloudfront.net/downloads/reviving_ocean_economy_report_low_res.pdf)

11 Estimate by The Economist Intelligence Unit, based on approximately 40,000 square km of mangrove cover in the Indian Ocean.

are often removed to improve port access. In Kenya, 100 ha of mangroves were lost as a result of dredging in the Sabaki river for an infrastructure project.<sup>12</sup>

Certain fishing practices can also be harmful. Seagrasses are often damaged when individuals dig up types of shellfish or collect bait species for larger fishing efforts. More destructive practices, such as dynamite fishing, are seeing an uptick in parts of Tanzania (Dar es Salaam and the Songosongo archipelago), although government intervention had succeeded in clamping down on this temporarily.<sup>13,14</sup>

The development of aquaculture has driven vast amounts of mangrove deforestation, particularly for shrimp farms in Thailand for which the environment around mangrove forests is ideal. Mangroves have been cut down in Thailand for palm oil production as well. Nutrient run-off from agricultural systems close to these habitats results in eutrophication, an oversupply of nutrients that leads to the growth of algae and eventually ocean deoxygenation.

In addition to some of these more direct impacts, the enormous pressures of climate change on the degradation of marine ecosystems must not be ignored. Roughly 40% of CO<sub>2</sub> emissions since the beginning of the industrial era have been absorbed by oceans,<sup>15</sup> leading to acidification. Rising atmospheric temperatures have led to ocean warming and deoxygenation.

Around the world, ocean warming has led to an increasing frequency of global coral bleaching events—in 1998, 2010 and 2015-16. Coral bleaching is the whitening of coral that results from the loss of a coral's symbiotic algae or the degradation of the algae's photosynthetic pigment<sup>16</sup>

and can be triggered with an increase in temperature of only two degrees centigrade. The death of coral reefs leads to a critical decline in ecosystem productivity, as fish species that depend on them for food and shelter perish or migrate, and coastlines erode rapidly without the coral's protection. Even if the target of 1.5°C for global warming under the Paris Agreement is met, it is estimated that 70-90% of reef-building corals will be lost.<sup>17</sup> Some reefs in Sri Lanka, the Maldives, India, Kenya, Tanzania and the Seychelles have experienced high coral mortalities of up to 95% as a result of warming.<sup>18</sup> In the western Indian Ocean, coral bleaching events in 1998 and 2016 resulted in 25% and 10% losses respectively,<sup>19</sup> resulting in direct financial losses to the diving industry estimated at US\$4m in Zanzibar, Tanzania, and US\$16m in Mombasa, Kenya, in 1998, according to one study.<sup>20</sup>

Furthermore, ocean warming, through melting glaciers at the poles and the thermal expansion of water, is contributing to rising sea levels. Global sea levels are expected to rise by 0.63 metres on average by 2100, with coastlines experiencing a sea-level change within a 20% margin of the global average.<sup>21</sup> Without the shoreline protection services offered by mangroves, coral reefs and seagrass meadows, the region's coastal population, estimated at over 250m, face a greater risk of displacement as sea levels rise.<sup>22</sup>

Many coastal areas lack effective frameworks for resource management and governance. In some there are financial constraints and in others commercial interests are prioritised over conservation. "More effort needs to go towards conserving and protecting the remaining habitats

12 E P Green and F T Short, World atlas of seagrasses. 2003

13 Coral reef status report for the Western Indian Ocean, <https://drive.google.com/file/d/1PkHG7-xSixodgvnbgYMoZjLjkQs2-.8p/view>

14 <https://www.wri.org/tanzania-deadly-dynamite-fishing-resurfaces>

15 Nature, Recent increase in oceanic carbon uptake driven by weaker upper-ocean overturning, <https://www.nature.com/articles/nature21068>

16 Encyclopaedia Britannica, Coral Bleaching, <https://www.britannica.com/science/coral-bleaching>

17 O. Hoegh-Guldberg et al., 2018, Impacts of 1.5°C Global Warming on Natural and Human Systems. In: Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.

18 Coral Bleaching in the Indian Ocean: SocioEconomic Assessment of Effects, [https://www.researchgate.net/publication/237453282\\_Coral\\_Bleaching\\_in\\_the\\_Indian\\_Ocean\\_SocioEconomic\\_Assessment\\_of\\_Effects](https://www.researchgate.net/publication/237453282_Coral_Bleaching_in_the_Indian_Ocean_SocioEconomic_Assessment_of_Effects)

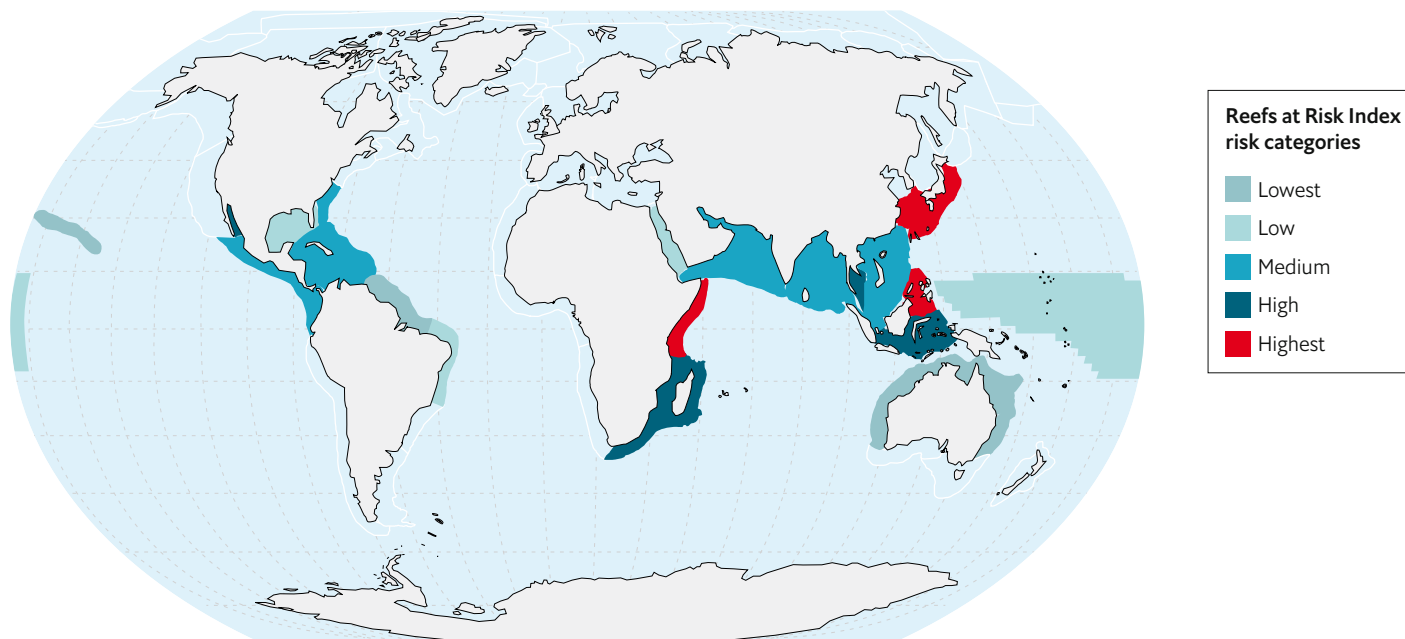
19 Coral reef status report for the Western Indian Ocean, <http://cordioea.net/gcrmnwio2017-2/>

20 Coral Bleaching in the Indian Ocean: SocioEconomic Assessment of Effects, [https://www.researchgate.net/publication/237453282\\_Coral\\_Bleaching\\_in\\_the\\_Indian\\_Ocean\\_SocioEconomic\\_Assessment\\_of\\_Effects](https://www.researchgate.net/publication/237453282_Coral_Bleaching_in_the_Indian_Ocean_SocioEconomic_Assessment_of_Effects)

21 IPCC, Climate Change 2014 Synthesis Report: Summary for Policymakers, [https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5\\_SYR\\_FINAL\\_SPM.pdf](https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf)

22 P Mondal and A J Tatem, Uncertainties in Measuring Populations Potentially Impacted by Sea Level Rise and Coastal Flooding, 2012, PLoS One, <https://journals.plos.org/>

## Reefs at risk



Source: IOC-UNESCO and UNEP (2016). Large Marine Ecosystems: Status and Trends, Summary for Policy Makers. UN Environment Programme. [http://onsharedocean.org/public\\_store/publications/lmes-spm.pdf](http://onsharedocean.org/public_store/publications/lmes-spm.pdf)

that we still have in place in order to maintain their ecological integrity,” asserts Mr Burt. “Expanding existing marine protected areas, developing networks of marine reserves, and heavily enhancing enforcement of maritime regulations and policies would go a long way towards preserving the important ecosystems that are still in place.”

Governments across the Indian Ocean Rim countries, in partnerships with global organisations and local non-government organisations (NGOs), are taking steps to establish marine protected areas, encourage environmental impact assessments and, most importantly, educate the local population to drive sustainable grassroots protection. “Protection of marine ecosystems is really a social challenge,” says Mr Wodehouse. “If you truly want to make an impact, it’s almost a village-by-village campaign, with boots on the ground, changing hearts and minds. It can be a slow, agonising grind.”

The case studies in this chapter take a closer look at some of these initiatives, weaving in these local, social considerations. In the Sri Lankan mangrove conservation project, we show how local commitment to mangrove

protection is secured in exchange for microloans and enforced by community organisations themselves; we reinforce the need for community-based monitoring in the story of seagrass protection in Thailand; and, finally, consider how the tourism industry in Zanzibar was trained to protect coral reefs and, in turn, their livelihoods.

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## CASE STUDY 1

**Manning mangroves: Sri Lanka's mangrove conservation project****Case summary**

- Through this project, Seacology (a US-based conservation organisation) aims to make Sri Lanka the world's first nation to comprehensively protect all of its mangrove forests.
- Seacology offered a unique deal across 1,500 villages situated near mangrove forests, trading a commitment to protect a mangrove forest or marine reserve for funding for a village project or microloans.
- Training is a vital component of the programme, as locals often have few business management skills, without which loans may be squandered.
- The support from the government has been critical to its success.

**A tragic history**

A lot was destroyed during the two-decade civil war in Sri Lanka between 1983 and 2009, and mangrove forests were among the collateral damage, serving as a hiding place for civilians and soldiers alike. Today, Sri Lanka has over 85 sq km of mangroves, but it is estimated that 74% has been lost since the 19th century.<sup>23</sup>

In the aftermath of the war and the 2004 tsunami that devastated coastal regions and livelihoods, many mangroves were cleared to make way for shrimp farming and to produce wood for fuel. Coastal development, primarily the construction of resorts, led to the vast deforestation of mangroves.

Mangroves are not only vital for the marine ecosystem, in that they replenish fish stocks and absorb excess nutrients, but they also limit coastal damage from storms or rising sea levels, crucial for an island like Sri Lanka. But most important is their ability to sequester carbon, in amounts much greater than other forests. Growing global awareness of this has galvanised political will in Sri Lanka too, where the government offered its full support for the conservation project led by Seacology, a US-based conservation organisation, in collaboration with a local NGO, Sudeesa. Through this project, Seacology aims to make Sri Lanka the world's first nation to comprehensively protect all of its mangrove forests.

**A successful trade: loans for conservation**

The first step in this effort was to map all existing mangrove areas. "This may come as a surprise," explains Duane Silverstein, executive director of Seacology, "but most countries in southern Asia do not have an accurate sense of where their mangroves are." Over 70% of the mangroves (around 60 sq km) have currently been mapped, but Mr Silverstein expects to accelerate these efforts as, since the project's inception, improvements in GPS technology have lowered costs for mangrove mapping. "The budget for mapping went way down," he exclaims.

Next, they had to enlist the local population. Among the biggest challenge Seacology faced in this effort was the poverty that drove locals to exploit the mangrove habitat in unsustainable ways. To provide a financial incentive, Seacology offered a unique deal across 1,500 villages situated near mangrove forests, trading a commitment to protect a mangrove forest or marine reserve for funding for a village project or microloans.

[plosone/article?id=10.1371/journal.pone.0048191#pone.0048191.s001](https://doi.org/10.1371/journal.pone.0048191#pone.0048191.s001)  
Seacology, The Sri Lanka Mangrove Conservation Project,

One recent beneficiary was 54-year-old Thavanesan Rageshwary, who ran a small retail shop in Mannar district before joining the Sri Lanka Mangrove Conservation Programme. The SLRs10,000 (US\$145) microloan and three-day training she received enabled her to expand her business. Her earnings have increased by SLRs5,000 a month and she is planning further expansion while managing and protecting the local mangrove forest.

The initiative focuses on such small-scale, win-win trade-offs. To date, Seacology has provided training on mangroves and business management, and disbursed microloans to 10,500 local women, many of them widows from the war.<sup>24</sup> In exchange, they have secured a commitment to help conserve, rehabilitate and replant mangrove forests along Sri Lanka's coasts. Roughly 30% of the US\$4m budget for this programme over five years was earmarked for microloans.

Training is useful, as locals often have few business management skills, without which loans may be squandered. Education on the value of mangroves is equally important. "People completely undervalue mangroves. This is because most people think of them as smelly, mosquito-infested swamps and a place where trash collects," explains Mr Silverstein. "Now they understand its value, such as nurseries for fish and other marine species." That these three elements—training, microloans and mangrove protection—are tied together is vital to the programme's success.

To enforce this, the programme has created "community benefit organisations" (CBOs). "These are very unofficial organisations, with about eight people but some have up to 30," describes Mr Silverstein. "These are also almost entirely made up of women, because one lesson I've learnt over 220 projects is, on an island, if you

# US\$4m

## Budget for mangrove conservation project in Sri Lanka

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**Seacology offered a unique deal across 1,500 villages situated near mangrove forests, trading a commitment to protect a mangrove forest or marine reserve for funding for a village project or microloans**

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24 Seacology, The Sri Lanka Mangrove Conservation Project, <https://www.seacology.org/project/sri-lanka-mangrove-conservation-project/>

want something done quickly and efficiently, have the local women do it.” Mr Silverstein cites their wide local networks, strong influence on the community and ability to get things done as reasons for why this is the case.

A recent change Seacology made was to disburse loans directly to the CBOs, instead of routing them through the NGO Sudeesa, giving the local community more administrative power. The CBOs also play an important role in monitoring and enforcement—applying social pressure to ensure mangroves are being protected and loans repaid.

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**“Seacology has ensured that the programme is truly grassroots and has secured the all-important public buy-in. “That’s the best way to make sure that protecting mangroves remains a priority,” says Mr Silverstein.**

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### Key ingredients for success

Through CBOs and the broad press coverage that the initiative has received, Seacology has ensured that the programme is truly grassroots and has secured the all-important public buy-in. “That’s the best way to make sure that protecting mangroves remains a priority even in the face of opportunities for economic growth such as building hotels for tourism,” says Mr Silverstein. More conversations

need to be had about generating value without degrading these habitats, such as through honey production.

The support from the government has been critical in this regard. “It’s very hard to go ahead if the government isn’t receptive,” says Mr Silverstein. The government has pledged to create a hotline to report illegal mangrove harvesting. Even the navy in Sri Lanka played an active role in planting and protecting mangroves. “One thing we tried to take into account though is that government officials come and go. We tried to set up a project that would outlive the turnover of a particular environmental minister or government [by focusing on common and long-term objectives for the project].”

The long-term view and preparation for “all the things that could go wrong” was the foundation on which this programme was built. They spent over a year on this analysis, but it allowed them to prepare for and altogether avoid some of those eventualities.

However, there is one change Seacology would have made, Mr Silverstein admits: offering microgrants instead of microloans. “Microloans are great and offer two main advantages—theoretically, the money repaid sustains an ongoing fund and people are educated on how loans work. But record-keeping for [a] grassroots organisation, to keep track of 15,000 loans of US\$100 each (in terms of how they’re being used and repayments) is very burdensome. So that’s a practical reason to go with microgrants.” It would also help sidestep the cultural challenge with the Muslim population (who make up 15% of Sri Lanka’s population) of charging interest on loans, which is prohibited in Islam.

### Conservation versus restoration

As part of the mangrove protection efforts, Seacology aims to replant 9,600 acres of destroyed mangrove habitat. As of July 2018, over 800 seedlings have been cultivated and 1,100 acres replanted. Initial reports have

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**Sri Lanka has opened the world's first mangrove museum. It has received 20,000 visitors in the first year, most of whom are students on field trips**

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shown an increase in fish and crab populations in the mangroves, but it is still too early to assess its full impact.

A noteworthy success is the higher growth in seedlings in Sri Lanka compared with projects around the world, says Mr Silverstein. "The reason for this is Sudeesa is using a combination of Western science and local knowledge in decisions on where, when and what to plant."

Dominic Wodehouse, an adviser at the Mangrove Action Project, involved in mangrove conservation projects around South-east Asia, concurs. "From a technical point of view, rehabilitation is more difficult than it looks. It's not like dryland forestry where you can grab some seeds [and] plug them in, in straight lines."

Planting targets set by governments further complicate this. Mr Wodehouse explains: "One village might be able to find 20 ha, for instance, to plant, but another village might not have the space. To meet the targets, they may plant 20 ha inappropriately and unsuccessfully." To avoid planting the wrong species in the wrong place, working with locals is imperative.

### **Educating to inspire**

To ensure a better understanding of the long-term value of mangrove conservation, education is vital. As part of this, Sri Lanka has opened the world's first mangrove museum. It has received 20,000 visitors in the first year, most of whom are students on field trips. Schools have also introduced education on mangroves as part of their curriculum. To commemorate the opening of the museum, the Sri Lanka Post has created a stamp on the museum and the 22 species of mangroves endemic to the country. "This kind of public education is exciting," says Mr Silverstein. Fostering a sense of responsibility and a deeper understanding of this valuable marine habitat at a young age will go a long way in ensuring that mangroves remain protected for years and decades to come.