This component of the toolbox will discuss how wetlands fit into the United Nations Framework Convention on Climate Change and the development of Reducing Emissions from Deforestation and Forest Degradation (REDD) programs.
Mangrove forest ecosystems covered 13.8 million ha of tropical shorelines in 2000 (Giri et al. 2011), down from 15.9 million ha in 1980 and 19.8 million ha in 1990 (FAO 2003). These losses represent about 2% per year between 1980 and 1990 and 1% per year between 1990 and 2000. Achieving no net loss of mangroves worldwide would require the successful restoration of approximately 150,000 ha per year, unless all major losses of mangroves ceased. (Lewis 2014)
While **conserving** mangroves (above) – full collaboration with local people is still a global priority...

...cost-effective **restoration** of destroyed and degraded mangrove systems (top and bottom right) is also of critical importance.
There are planting failures: Unfortunately – the majority of mangrove restoration projects fail worldwide – representing a waste of resources and discouraging to those involved in the effort. Most mangrove rehabilitation activities involve the oversimplified act of planting one or a few species of mangrove propagules from the family Rhizophoraceae in mud flats inappropriate for mangrove growth.
Mangroves grow between mean sea level (MSL) and highest astronomical tide (HAT). At any given location around the world, between 1–32 species of mangroves may inhabit this zone, each adapted to a different level of tolerance to the duration and frequency of tidal inundation.
However – humans often plant the wrong species of mangrove in inappropriate locations – usually in a tidal mud flat below mean sea level. This occurs because these mud flats appear to be empty (devoid of mangrove vegetation) and more importantly because there are no land tenure issues to resolve in sub-mean sea level mudflats.
Learning Hydrology: Successful mangrove forest restoration requires careful analyses of a number of factors before attempting actual restoration. Lewis (2005, 2009) notes that existing hydrology of a proposed restoration site needs to be characterized and compared with that of a reference forest to establish what conditions preclude natural recovery in damaged forests.
6 Steps to Successful
Ecological mangrove rehabilitation (EMR):
Work together with local communities, NGOs and government to:

1. understand both the individual species (autecology) and community ecology of the naturally occurring mangrove species at the site, paying particular attention to patterns of reproduction, distribution, and successful seedling establishment;

2. understand the normal hydrology that controls the distribution and successful establishment and growth of targeted mangrove species;

3. assess the modifications of the mangrove environment that occurred and that currently prevent natural secondary succession;

4. select appropriate restoration areas through application of Steps 1-3, above, that are both likely to succeed in rehabilitating a forest ecosystem and are cost effective. Consider the available labor to carry out the projects, including adequate monitoring of their progress toward meeting quantitative goals established prior to restoration. This step includes resolving land ownership/lease issues necessary for ensuring long-term access to and conservation of the site;

5. design the restoration program at appropriate sites selected in Step 4 above, to restore the appropriate hydrology and utilize natural volunteer mangrove recruitment for natural plant establishment;

6. utilize actual planting of propagules or seedlings only after determining through Steps 1-5, above, that natural recruitment will not provide the quantity of successfully established seedlings, rate of stabilization, or rate of growth as required for project success.

(De Breuyn et al. 2000, Semeni, 2002)
The EMR process strives to involve people in all phases of a restoration project; including assessment, design, implementation and monitoring for a period of at least 3 years, to inform mid-course corrections.
EMR was first practiced in the United States. In this project in West Lake, Florida – invasive *Casuarina* pine growing on unnaturally elevated dredging tailings needed to be removed.
The area was re-graded using heavy machinery and tidal creeks were created (re-iterating tidal creek morphology from a nearby reference forest) to facilitate natural flooding and drainage of the restoration site.
Within a number of years, the area began to regenerate naturally – due to the presence of nearby “mother trees”. No trees were planted by humans in this project, which restored a full range of local mangrove species, canopy closure and fisheries values.
ERODING ENVIRONMENTS: Whereas the previous three slides show EMR in an accreting environment, EMR may also be attempted in an eroding environment. This is due to high global incidence of coastal abrasion compounded by sea level rise. No technique can promise to reverse the effects of coastal subsidence and erosion without addressing larger landscape or watershed scale issues of degradation

Above: Re-grading a vertical erosion bluff in Cargill, Florida which was subsequently hand planted with halophytic grass (Spartina spp.). The grass serves to stabilize the re-grade, enhance edaphic conditions in the substrate and physically capture mangrove seedlings. A decade later, the Spartina has been replaced with several mangrove species.

Below: This low rock break-wall was installed at Pelican Island, Florida, to capture sediment. After installation, both halophytic grass and mangroves were able to colonize newly elevated surfaces and persist over time.
In this example, an abandoned shrimp pond in North Sulawesi was experiencing natural regrowth where dike walls near to the sea were eroding. However, further inland – natural recovery was inhibited by poor hydrology due to the presence of dike walls and artificial canals.
A design was created in partnership with the community of Tiwoho village, the University of Sam Ratulangi and a local NGO (Yayasan Kelola) to strategically breach dike walls and fill in the artificial ditches which drained the shrimp ponds.
Local villagers strategically breached dike walls and filled in artificial canals – using hand tools at a very low cost. Note: the stakes in the photo are from a failed government planting prior to hydrological restoration, the sixth failed planting over nine years.
Time zero plus 12 months
A total of 21 species of mangrove have now recolonized the 20 hectare restoration site, with densities ranging from 9467–27,093 stems/ha.
Prior to restoration, ponds in section C exhibited some degree of natural revegetation from 1991 and 2003. Mangrove growth in sections, A, B and D, however, was negligible due to disturbed hydrology and hypersaline conditions.
Eight years after EMR, Section A, C and D have experienced canopy closure, a sign of successful restoration. Section C is still suboptimal, and could benefit from the creation of a tidal creek draining the area from the bottom left to the upper right corner.
After achieving success at small scale (10–20 hectares), EMR was up-scaled in Indonesia on Tanakeke Island, in South Sulawesi. 500 hectares of disused shrimp ponds were restored between 2011 and 2015. These ponds developed during the aquaculture expansion known as the Blue Revolution, have been abandoned as communities struggled with shrimp farming, and shifted their livelihoods to seaweed mariculture in sub-tidal lagoons.
This medium-scale restoration project (480 hectares) was achieved through the use of hand tools, breaching dike walls and creating several kilometers of tidal channels. Communities periodically distributed mangrove propagules by hand, to speed up colonization by mangroves.
The chart above depicts stem density per hectare, both per species and also as a total (dark blue) over 32 months following restoration at Lantang Peo village, one of six restoration sites on Tanakeke Island.

This rather low density can be expected at Tanakeke, a coral atoll, with only 15–20 cm of soil and organic matter above a coral substrate and very little freshwater inputs.
Sustainable Livelihood development takes place from the onset of a program, and continues as communities wait for mangroves to grow and fisheries habitat to improve. A program known as Coastal Field School has been developed and adopted by the government to improve management of coastal resources and develop critical thinking skills amongst fishers.

Nypah palm sugar production (top left and right), fish farmer field school (bottom left) and introduction of fuel-efficient cooking stoves (bottom right) are three examples of livelihood activities which have been successfully developed in conjunction with EMR.
ADAPTIVE COLLABORATIVE MANAGEMENT

To ensure the long-term conservation and sustainable use of mangroves after rehabilitation, empowered community members and government work side by side in mangrove management.

In Indonesia, the National Mangrove Strategy, mandates that *Multi-stakeholder Mangrove Working Groups* are set up at the provincial and district levels for adaptive management.

A newly formed mangrove management working group from Papua visits their counterparts in Sulawesi, in order to learn about the key steps to successful adaptive collaborative management (*above left*).

A woman’s group in Sulawesi measures mangrove pneumatophores to study how mangroves adapt to sea level rise. (*bottom left*). This information is shared with the mangrove management working group, who use such information to adjust their longer term management plans.
SCALING-UP

There is great potential in Indonesia and elsewhere around the world for large-scale mangrove restoration, but resources are limited. EMR provides a cost-effective, proven process for restoration of a biodiverse mangrove ecosystem which will function and adapt to changing environmental conditions over the long term.
For more information see:
www.mangroverestoration.com
(over 100 free scientific papers)

Download our free 275 pp EMR manual
(left - download #00) with international
case studies.
References


