MANGROVE REHABILITATION AND CONSERVATION

RJA LOMA, JD COCHING, CL MONTILIJAO, JP SAVARIS, JH PRIMAVERA
The Zoological Society of London

Founded in 1826, ZSL is an international science, conservation and education charity (no. 208728), whose mission is to promote and achieve the worldwide conservation of animals and their habitats. ZSL pursues this mission through three main fields of activity:

- Conservation - ZSL’s Conservation Programmes department is actively involved in field conservation in over 50 countries worldwide. ZSL’s wide-ranging conservation work aims to build capacity and influence policy, to bring direct and sustainable conservation benefits to wild animals and their habitats, with activities typically undertaken by forming partnerships with local organisations and government departments;
- Science - the Institute of Zoology identifies, undertakes and communicates high quality biological research relevant to the conservation of animals and their habitats;
- Education and inspiration - ZSL presents and interprets outstanding living collections of animals at ZSL London Zoo and ZSL Whipsnade Zoo. The zoos receive around 1.5 million visitors a year and are supported by some 250 volunteers.

ZSL’s strategic aims are to: undertake and promote relevant high quality zoological and conservation research to help achieve our conservation objectives and to inform and influence conservation policy; encourage and motivate all stakeholders to support and engage in conservation; and to implement and achieve effective and appropriate in situ and ex situ conservation programmes for priority species and habitats.

Darwin Initiative

The Darwin Initiative is a UK government grants scheme that helps to protect biodiversity and the natural environment through locally based projects worldwide. The Initiative funds projects that help countries rich in biodiversity but poor in financial resources to meet their objectives under one or more of the following biodiversity conventions: Convention on Biological Diversity (CBD), Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), Nagoya Protocol on Access and Benefit Sharing, and International Treaty on Plant Genetic Resources for Food and Agriculture. Projects typically try to address threats to biodiversity such as over-exploitation, invasive species, habitat degradation and loss, climate change mitigation and adaptation, and pollution.

Turing Foundation

The Turing Foundation is a Netherlands-based private charity established in 2006. It seeks to promote and encourage a sustainable and respectful relationship with nature. Respect is in the interest of nature itself. Sustainability ensures that the needs of present generations can be met, without reducing the possibilities of future generations to fulfill theirs. In trying to achieve these aims, the Turing Foundation limits its scope to the protection and sustainable management of the nurseries of the sea in developing countries, the areas in seas and along coasts that have the highest concentration of life and biodiversity, and sustainable organic agriculture and cattle breeding (in developing countries in Africa).
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Front cover: Mangrove planting by members of the Buntod Katibyugan ka mga Mangingisda kag Kababaenan in Barangay Buntod, Panay, Capiz (photo by Armi May T. Guzman)

Back cover: Nabitasan Katunggan Ecopark in Barangay Nabitasan, Leganes, Iloilo as a learning destination for participants of the Training of Trainers on Mangrove and Beach Forest Conservation and Rehabilitation, 26 November 2015 (photo by Vincent Gado)

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Download document at: www.zsl.org/mangroves
Mangroves are plants which predominantly grow in the intertidal area of tropical and subtropical shorelines. The widest mangrove area and most species are found in Southeast Asia.

They can tolerate saltwater and oxygen-poor soil. They have propagules able to survive in, and dispersed by, seawater.
Mangroves are exclusively found in the upper to middle intertidal zone, submerged in seawater during spring high tide and exposed to air during neap low tide. Their associates are distributed above the high tide or high water line.

Mangroves are above seawater 70%, and are flooded only 30%, of the time. In the lower intertidal and subtidal zone are seagrasses and coral reefs.
Mangroves are important

Mangroves offer various ecosystem services that are beneficial to the environment and to people.

**Value of mangrove ecosystem services**

- **Coastal protection**: $8,966 – 10,921 US$/ha/yr
- **Erosion control**: 3,679 US$/ha/yr
- **Raw materials and food**: 484-585 US$/ha/yr
- **Maintenance of fisheries**: 708-987 US$/ha/yr
- **Carbon sequestration**: 30-50 US$/ha/yr

Barbier et al. 2011

**Coastal Protection** *(lessen impact of wave action)*

**Fisheries** *(providing food and nutrients for marine organisms)*
**Biofiltration** *(root systems trap sediment)*

**Sediment Trapping and Stabilisation**

- wetland pool
- salt flat
- salt marsh
- mangrove zone
- intertidal mudflat
- subtidal zone

**Habitat to wildlife** *(breeding, nursing, and feeding ground of various animals)*

- Crocodile (savesundarbans.com)
- Tiger (culturebowl.com)
- Kingfisher (John Parker/SERC)
- Heron (John Parker/SERC)

**Carbon sequestration** *(removes carbon dioxide from the atmosphere and acts as carbon storage)*

- Oxygen gas (O₂)
- Carbon dioxide (CO₂)
- Carbon (C)
What are the threats to mangroves?

Mangroves are constantly threatened by both anthropogenic and natural factors. Anthropogenic factors pose greater threat to mangroves and conversion into aquaculture fishponds is the major cause of mangrove loss.

Aquaculture ponds

Google Earth 2018

<table>
<thead>
<tr>
<th>PHILIPPINES</th>
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</thead>
<tbody>
<tr>
<td><strong>Mangroves</strong></td>
<td><strong>Ponds</strong></td>
</tr>
<tr>
<td>1918: 450,000 ha</td>
<td>1940: 61,000 ha</td>
</tr>
<tr>
<td>2003: 220,000 ha</td>
<td>1994: 232,000 ha</td>
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</tbody>
</table>

Present Mangrove : Pond Ratio - 1:1
Ideal Ratio (Saenger et al. 1983) - 4:1
The Philippines mainly has semi-diurnal tides, with two tidal cycles - minor and major cycles - over a 24-hr period. 

**NEAP TIDE** occurs during the First Quarter and Last Quarter of the lunar cycle, characterized by a lower tidal range. 

**SPRING TIDE** occurs during the New Moon and Full Moon of the lunar cycle, characterized by a higher tidal range.

Tides and planting sites

**NEAP TIDE** and **SPRING TIDE** tides occur alternately twice every month, simultaneous with the lunar cycle.
Mangrove planting sites should be exposed during **NEAP TIDE**. These are the upper to middle intertidal areas and remain above seawater 70% of the time, a prerequisite for mangrove survival. Biophysical and socio-economic considerations are listed in the site selection checklist for mangrove rehabilitation.

<table>
<thead>
<tr>
<th>BIOPHYSICAL</th>
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<tbody>
<tr>
<td><strong>a) Nursery</strong></td>
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<td>substrate firm</td>
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<td>substrate flat</td>
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<td>well-drained location</td>
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<td>presence of trees for shade</td>
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<td><em>first 5 criteria should be YES</em></td>
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<td><strong>b) Outplanting: seafront and outer abandoned pond</strong></td>
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<td>exposed during neat tide (low tide)</td>
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<td><strong>c) Outplanting: inner abandoned pond</strong></td>
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<td>SOCIODECONOMIC</td>
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### Preparation for field activities

1. **Consult a tidal calendar** or commercial calendars (with tide levels) to select suitable date and time.
2 Wear appropriate clothes, rubber shoes/booties.

3 Prepare logistics and materials.
Transportation, drinking water, snacks, first aid kit, bagging and planting materials

Bagging activity
- shovel, digging blade, trowel
- seedling polybags
- wildings - 8 x 12” (20 x 30.5 cm)
- seeds - 4 x 6” (10 x 15 cm)

Planting activity
- seedlings (nursery or wildings)
- seedling carriers
- shovel, digging blade, trowel
- meter stick
- bamboo stakes (1 m long)
- pre-cut strings (20 cm long)
Why establish a nursery?

- Nursery-reared plants are sturdier
- Small seeds are not suitable for direct planting
- Seafront survival: higher for nursery-reared seedlings (vs. propagules)
Nursery site selection

Natural tidal flow/inundation during spring tide

Protected from waves

Under the shade of mangrove/other trees

Flat, firm substrate, well-drained

Proximity to planting site

Preferably close to seed/propagule source
Bagging of mangrove wildings

1 Briefing/Orientation

- Ratio of 1 instructor/facilitator: 15-20 participants
- Divide into seed/wilding collectors, baggers, haulers

Arrive at least 1 hour before the targetted low tide level.

2 Look for “seedling banks”

- Sea strand/swash zone
- Under mother trees
- Dikes of abandoned fishponds
3 Collect wildings

- Plants not more than 40 cm high
- With at least 6 leaves for *Avicennia* spp.
- Use shovel or digging blade
- Soil should still be attached to the roots

4 Conditioning in the nursery

- Smaller wildings (10-20 cm) = 3-12 months until they reach 30 cm and stems are hardened
- Bigger wildings (20-30 cm) = may be transplanted directly
Collection and bagging of seeds and propagules

Collection during the peak of fruiting season.

Check the color and texture for maturity. Exclude fruits with damage.

Check viability of \textit{Rhizophora} propagules in mud.
Propagules should not be transported between islands. This will avoid possible transfer of disease and potential negative impacts on the local gene pool.

Store in shady, cool and dry place and plant within 1 week to 1 month depending on species.

Sow and germinate seeds. Water and protect from pests.
Nursery maintenance

Visit nursery at least 2-3 times weekly.

Remove diseased plants and bury them.

Place plastic sheet lining so roots do not penetrate the ground below seedling bags.

If seedlings are stunted due to small bags or roots emerge from the plastic bags, transfer to bigger bags.

Pest: *Coccotrypes fallax*
Remedy: sun-dry or air-dry for 1-2 weeks prior to planting in polybags.
### Site selection

#### BIOPHYSICAL

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#### Site selection for seafront planting

1. Go to potential seafront site during **NEAP TIDE**.

2. Delineate and mark boundaries of suitable areas.

3. Designate navigational lanes for areas with fishing boats.

4. Note remarkable features such as creeks and waterlogged areas where seedlings may drown.

Site selection is critical for seafront planting because area available is mostly lower intertidal, in contrast to abandoned ponds.
Mangrove outplanting strategy

**WHAT to plant**

Select species naturally found in the area.

Common mangrove colonizers typically found in fringing mangrove stands are *Avicennia marina*, *Sonneratia alba* and *Rhizophora* species. The latter are found behind the frontliners *A. marina* and *S. alba*.

Mangrove species zonation is influenced by factors such as salinity, elevation and substrate type.
Bigger wildings may be directly planted.

Nearby wildings may also be directly planted in abandoned ponds and for enrichment planting of inner seafront sites protected from wave action.

Planting materials can be sourced from nurseries.

Seedling sizes for planting will depend on location and substrate. Seafront/outer abandoned ponds/muddy portions of ponds - bigger sizes at least 50 cm to 1-1.5 m high; inner abandoned ponds - smaller sizes at least 30 cm high.
WHEN to plant

Season
Season with least wave action. Strong wind and wave action can uproot (left) or bury (right) planted seedlings under the sediment.

Time
Early morning or late afternoon

Tide
Consult tidal calendar for daytime low tide
**HOW to plant**

**Density**

**Seafront/outer abandoned ponds**
- Closer distance/higher density
- 0.5 m x 0.5 m to 1 m x 1 m

**Inner abandoned ponds**
- Wider distance/lower density
- 1.5 m x 1.5 m to 2 m x 2 m

**Strip planting**
- Planting of 2-5 rows closest to the mangrove area
- Additional rows further away when seedlings grow bigger

**Cluster planting**
- 2-3 seedlings planted per hole
- Can also be done during bagging
Pattern

zigzag pattern of individual plants

rows planted from landward to seaward (pa-abante)

Steps in mangrove outplanting

1 Briefing/Orientation
   • Ratio of 1 instructor/facilitator: 15-20 participants
   • Divide into groups for hauling, making lines, digging holes, distributing seedlings

2 Make parallel lines as guides
   • Seafront - 0.5 m to 1 m
   • Abandoned ponds - 1.5 m to 2 m
   • Enrichment planting - vacant spaces ≥ 2 m²
3 Mark with bamboo stakes on points for holes

4 Dig holes at marked points
• ~30 cm deep by ~20 cm wide

5 Haul nursery seedlings or wildings to planting site

6 Place seedling inside hole
• Keep the soil intact and do not damage the roots
• The top of the plant soil should be level as the ground

7 Fill in remaining space with soil
- **bagged seedlings** - tear polybag on side & slowly remove plant
- **wildings** - keep all attached soil by earthballing
- **propagules** - remove caps & bury 1/3 of the propagule length

8 Secure stakes 3-5 cm from the plant

9 Tie plant to the stake using pre-cut string

10 Collect discarded polybags and other garbage
  - Do not leave trash on site
Fixed-point quadrat method

- Preferred way of monitoring mangrove survival and growth
- Advantage with large scale rehabilitation projects

1. Count total number of plants within the 100 m² quadrat on the day of planting (this is baseline data)

2. Return to the site noting the date and count all surviving plants

3. Compute survival rate (%)

   \[ \text{Survival rate} \% = \frac{\text{No. of survivors}}{\text{Initial no.}} \times 100 \]

Frequency of monitoring
- Month 1-3: monthly
- Month 4-12: quarterly
- Month 12-48: biannual
- >48 months: annual
Community decision tree

START HERE
How many plants have survived?

>50%
Do the remaining plants appear healthy?

NO
Remove excess algae

Remove barnacles (particularly from *Rhizophora*)

Check whether the site is waterlogged

Replace plant if necessary and monitor again in one month

<50%
Is the site flooded at neap low-tide?

NO
Is substrate suitable and stable enough or are plants being eroded/waterlogged?

YES
Review site selection criteria and consider alternative planting site or whether interventions required (e.g., barriers, breakwaters)

NO
Could propagules/seedlings be of poor quality

YES
Has the species been selected to match the site characteristics?

NO
Are there any signs of pests?

YES
Could mortality be caused by people/animals e.g. boat traffic, gleaners, goats?

NO
Install barriers e.g. fences, signs

Ensure (e.g. through PO, LGU, bantay gubat) mangrove policies being followed

Monitor again in one month

YES
Replace plant if necessary and monitor again in one month

NO
Remove algae/barnacles

Replace plant if necessary and monitor again in one month

Replace dead plants with new batch

Replace plant if necessary and monitor again in one month

Review species selection (Table 2) and repeat planting with correct species

Consult experts

Replace plant if necessary and monitor again in one month

Review site selection criteria and consider alternative planting site or whether interventions required (e.g., barriers, breakwaters)
**PROTECTION AND MAINTENANCE**

**Physical threats**

**Wave action**
- Encountered in seafront areas or seaward portion of abandoned ponds without dikes
- Can topple down or burry newly planted seedlings

**Erosion**
- Caused by wave action
- Common in seafront areas or seaward portion of abandoned ponds

**Solution**
- Install barriers or breakwater

**Burial of seedlings**
- Caused by sedimentation
- Can cover leaves of small seedlings, leading to plant death

**Solution**
- Plant taller seedlings (>50 cm)
- Transfer planting site, if burial by sedimet continues
Biological threats

Insect infestation
- Mangrove moth larvae (<em>Aucha velans</em>) feed on <em>bungalow/pia</em> leaves
- Scolytid beetle (<em>Coccotrypes fallax</em>) infests Rhizophora seedlings and propagules

Solution
Avoid monoculture plantations particularly in seafront areas
- Constant monitoring of planted and nursed seedlings
- Remove seedlings that show signs of infestation
- Remove dying and dead seedlings and dispose by burying or burning

Oysters and Barnacles
- Adhesive cement of barnacles may affect growth negatively
- Weighs down plant and may cause breakage
- Rhizophora spp. (bakhaw) more prone to barnacle infestation than <em>S. alba</em> (pagatpat) or <em>A. marina</em> (bungalow/pia)
Filamentous algae infestation
- Frequent in areas near fishponds
- Peaks during summer
- Chokes and weighs down seedlings causing breakage, specifically in *A. marina* (not *S. alba*)

Solution
Manual removal from plants
- Use of long-nose pliers and thick gloves
- Plant pagatpat seedlings in areas prone to barnacle infestation

Solution
Manual removal of algae from seedlings using scissors
- Easier if algae still wet and/or floating
- Dispose of collected algae on higher ground or bury deep in the ground to prevent being washed back to the planting site
- Plant *S. alba* (pagatpat)
Man-made threats

**Fishing gears, boat traffic, gleaners, domestic animals, large debris**
- Physically damage plants
- Can cause breakage, uprooting, defoliation of plants

**Solution**
- Install floating markers and signage around the planting area
- Bamboo poles with packaging straps to serve as fence visible at high tide
- Hire caretakers for areas with no organized community
- Regular visits to plantation to remove debris
## INVOLVING COMMUNITIES IN MANGROVE REHABILITATION

### Site selection

<table>
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<tr>
<th>SOCIO-ECONOMIC</th>
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<td>Easy to work with</td>
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<td>Willing to provide counterpart funds</td>
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<td>Willing to have their staff trained</td>
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<td><strong>5/6 criteria should be YES</strong></td>
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Organizing communities

Defined as the process by which the community identifies its needs and objectives, develops confidence to take action, and in doing so extends and develops cooperative and collaborative attitudes and practices.

Process

1. **Forge agreements with partners (Year 1)**
   Partners must develop and sign legal agreement in the form of a Memorandum of Agreement (MOA).
   - Pay courtesy call on the LGU
   - Present the project
   - Define roles and responsibilities
   - Draft and review MOA with partners
   - Sangguniang Bayan authorizes the Mayor to sign MOA with partners
   - MOA signing

2. **Get to know the community (Year 1)**
   Community organizer is immersed in the site to familiarize and identify potential leaders using a set of criteria.
   
   Training of Local Research Assistants to establish the situation of the area using participatory methods.
3 Form and re-build People’s Organization (Year 1)
Formation in areas without POs or conduct of Organizational Diagnosis in areas with existing POs

4 Build capacity of PO (Year 2-4)
Actions taken to improve effectiveness and enhance ability to achieve mission

Approaches
- Conduct of trainings and seminars
- Mobilize and engage communities
- Implement alternative livelihoods project using mangroves as the base resource to augment existing income
5 Secure tenure and sustain community initiatives
Mangroves need long-term management and through sustaining mangroves that communities benefit from its ecosystem services

Approaches
- Assist PO in applying for tenure such as Community-based Forest Management Agreement (CBFMA)
- Mainstream mangrove agenda with the LGU
- Maintain partnership and linkage with LGUs and schools
- Promote no-pay planting
- Formulate PO strategic plan

Mangrove rehabilitation plan
A mangrove rehabilitation plan is a sequence of steps to achieve the goal of restoring mangroves to good condition, operation, or capacity. It explains in detail what needs to be done, when, how and by whom.

Why do we need a plan?
- To serve as guide in the day-to-day activities
- To ensure that the targets are achieved in a given time frame
- To ensure that resources are adequate and they are maximized
- To distribute tasks among members
• To estimate the number of seedlings needed taking into consideration spacing and species appropriate for planting
• To serve as basis for evaluation and decision-making

**Parts of the plan**

1. **Name of the project**
2. **Objectives**
   SMART (simple, measureable, attainable, realistic, and time-bound)
3. **Brief description of the area**
   Basic demographics, location of sites, current mangrove status, presence or absence of communities, possible involved parties
4. **Defined area/ location of planting site**
   Map area showing the mangroves, where to establish nurseries, outplanting areas, areas for protection
5. **Seedling requirement**
6. **Materials needed**
7. **Set of activities**
8. **Schedule and Budget of Activities**

<table>
<thead>
<tr>
<th>Activities</th>
<th>Timeframe</th>
<th>Responsible person</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project preliminaries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site assessment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursery establishment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outplanting</td>
<td></td>
<td></td>
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<tr>
<td>Monitoring and maintenance</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>
REFERENCES


“The potential of coastal mangrove greenbelts to mitigate sea level rise and increasing storm frequency and intensity caused by climate change cannot be over-emphasized. Rehabilitate mangroves we must, but let us follow science-based guidelines.”

Jurgenne H. Primavera, March 2010