TAKE-HOME MESSAGES

Rehabilitation of mangroves in abandoned aquaculture ponds has greater benefit for returning high carbon storage and coastal protection than
Current greenbelt laws of 50-100m may be too narrow for effective coastal protection.
Abandoned ponds of >370m landward greenbelt width should be prioritised, as these can produce effective coastal protection within
Mangrove greenbelt rehabilitation efforts should target reversion of large areas of sea-facing abandoned ponds where tenure status is favourable; e.g. Fishpond Lease Agreements (FLAs) that have expired or are due for cancellation because of violations of lease conditions.
Rehabilitation of abandoned ponds for high carbon storage and coastal protection will require regular monitoring of mangrove growth and possible active assisted rehabilitation (planting).
Maintenance of partial seaward pond dikes may enhance vegetation establishment and sediment carbon storage, and reduce erosion.

Rehabilitating mangrove ecosystem services: a case study on the relative benefits of abandoned pond reversion from Panay Island, Philippines

Clare Duncan, Jurgenne H. Primavera, Rona Joy A. Loma, Heather J. Koldewey

ZSL | LET'S WORK FOR WILDLIFE

BACKGROUND TO STUDY

Mangrove greenbelts provide means to reduce climate change impacts and protect coastal infrastructure and communities under predicted climate change-driven increases in storm intensity. Much natural mangrove greenbelt has been lost in the West Visayas due to clearing for pond aquaculture under titled ownership, FLAs and illegal/undocumented ponds. National greening programmes have prioritised planting in low-intertidal and sub-tidal areas. However, this has the potential to damage other ecologically-important habitats (seagrass beds and mudflats), have low survival rates, and established narrow replanted strips may have limited ability to provide strong coastal greenbelt protection and carbon storage. Instead, prioritising reversion of abandoned aquaculture ponds could hold promise for rehabilitating effective mangrove greenbelts with high carbon storage. It is thus important to understand the relative carbon storage and coastal protection potential of rehabilitated mangrove greenbelt under seafront replanting and abandoned pond reversion, and potential gains in these from abandoned pond rehabilitation at regional levels.

METHODS

- Two abandoned ponds (Nabitasan, Leganes; Dumangas); two rehabilitated seafront areas and adjacent natural areas (Ermita, Dumangas; Bakhawan ecopark, Kalibo).
- Mangrove community structure surveys (n=8 per site).
- Carbon stock assessments: allometric equations, and sediment carbon analysis (Bureau of Soils and Water Management, Cebu).
- Coastal greenbelt width requirement modelling: existing models in scientific literature.
- Abandoned pond mapping from high resolution satellite imagery (Dumangas municipality).
- Predicting total carbon gains of reversion of all abandoned ponds from field data (vegetation growth and new sediment formation and trapping; Dumangas municipality).
- Geographic Information Systems (GIS) analysis of available abandoned pond landward greenbelt width (Dumangas municipality).
- Tenure status for abandoned ponds identified with effective greenbelt width after eight years (Dumangas Municipality; ZSL-Philippines).

PRINCIPAL RESULTS

- Site-level carbon storage was high at abandoned pond sites, due to large areas (Figure 1).
- Total carbon storage per hectare was greater in abandoned ponds than in seafront rehabilitated areas due to high sediment carbon storage (Table 1).
- Abandoned ponds rehabilitated with dense vegetation required landward greenbelt widths of 370m eight years following reversion, and mature natural mangrove structure required >200m of greenbelt.
- Abandoned ponds had large landward greenbelt widths relative to typical seafront rehabilitated areas (Table 1). Where vegetation density was high these ponds were sufficiently large to provide effective coastal protection eight years following rehabilitation, while typical seafront rehabilitated areas were not.

Figure 1. Satellite view of all study sites' rehabilitation area size (hectares) and size relative to the Ermita, Dumangas seafront rehabilitated site (bottom-left panel). Top-left panel: Dumangas abandoned pond; top-right panel: Nabitasan, Leganes abandoned pond; bottom-left: Ermita, Dumangas; bottom-right: Bakhawan Ecopark, Kalibo.

- Low vegetation cover and biomass at Nabitasan, Leganes (Figure 2) highlighted a need for continued monitoring and assisted rehabilitation (planting) during abandoned pond reversion where natural propagule availability/establishment is low.
- Exceptionally high sediment carbon storage at the Dumangas abandoned pond site may suggest a benefit to maintenance of partial seaward pond dikes for trapping sediment and organic matter in recovering ponds.
- Pond abandonment was high in Dumangas (~380ha), and it was estimated that 5,800-8,000 tonnes of carbon could be stored into vegetation growth and new sediments over 6.5 years following reversion.
- 31% of Dumangas' coastline was fringed by abandoned ponds (all >100m landward greenbelt width); 13% was fringed by abandoned ponds with potential future effective landward greenbelt widths >370m.

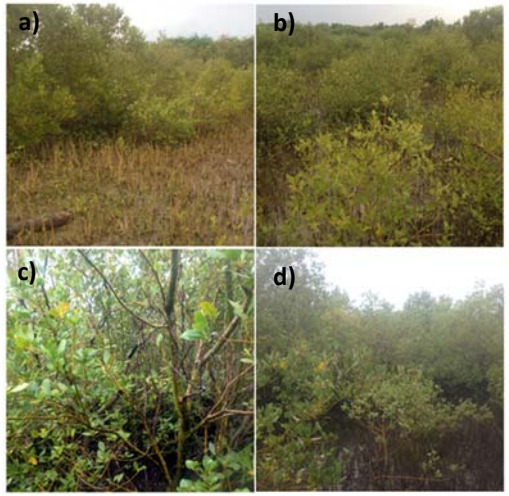

Figure 2. Areas of a) Sparse and b) short *Avicennia marina* at Nabitasan, Leganes abandoned pond, and c) dense and d) tall *Avicennia marina* at Dumangas abandoned pond.

- 97% of these sea-facing abandoned ponds of >370m landward greenbelt width are held under FLAs, and thus BFAR, DENR and the LGUs should integrate/harmonize efforts to enforce the legal mandate (DENR M.O. 3 (1991); Joint DA-DENR Gen. M.O. 3 (1991); F.A.O. 197 (2000)) to revert abandoned ponds back to mangroves.

Table 1. Details of seafront and abandoned fishpond rehabilitated study sites, including their intertidal position, age since rehabilitation, area, landward width, total carbon storage (C) per hectare (above- and belowground vegetation carbon and sediment carbon storage), and specific remarks.

Site	Intertidal location	Age (years from rehabilitation)	Area (hectares)	Landward greenbelt width	Average C (tonnes per hectare)	Remarks
Ermita, Dumangas	Low-intertidal	7	0.5	41	172.2	Monoculture *Sonneratia alba*
Bakhawan ecopark, Kalibo	Low- to mid-intertidal	8	19.5	186	151.3	Unique large seafront rehabilitation site (after over-cutting). Planting and natural colonisation (higher species diversity).
Nabitasan, Leganes pond	Mid-intertidal	5	9.1	268	212.2	Seaward dike absent; high erosion at seaward edge. Young, sparse *Avicennia marina*.
Dumangas pond	Mid-intertidal	8	46.0	827	710.4	Seaward dike ~75% remaining; organic matter and sediment trapping. Dense *Avicennia marina*.

Duncan, C., Primavera, J.H., Pettorelli, N., Thompson, J.R., Loma, R.J., Koldewey, H.J. (2016). Rehabilitating mangrove ecosystem services: a case study on the relative benefits of abandoned pond reversion from Panay Island, Philippines. *Marine Pollution Bulletin*, 109, 772-782.