Mangrove restoration for nature-based shoreline protection and management, Corozal, Belize

Sharook Madon – Jacobs, San Diego, CA, USA
Project Overview – Geographic Location
Project Overview – Ecosystems and Economy

- Belize coastline supports diverse ecosystems
  - Mangrove forests
  - River deltas
  - Sea grass beds
  - Estuaries
  - Coastal lagoons

- Coastal area supports economic and social activities
  - Tourism, fisheries, agriculture, manufacturing, urban development
Project Overview – Threats

• Coastal zone faces many threats
  – Natural disasters (in hurricane belt)
  – Climate change
  – Coastal flooding and erosion

• These pose a threat to Belize’s sustainability and its important economic sectors
  – In particular, tourism, its largest earner of foreign exchange
Project Overview – Threats

• Other threats contributing to coastal vulnerability
  – A lack of, or poorly enforced natural resource and land use regulation
  – Environmental degradation
  – Unchecked development
  – Poor construction standards
  – Human settlements
The Belize Integrated Coastal Zone Management Plan (BICZMP) was published in 2016.

BICZMP Goals:
- Promote sustainable development of coastal and offshore areas
- Protect and preserve the traditional way of life
- Ensure sustainability of coastal resources.
Project Overview – Resilience in Sustainable Tourism

• This project builds on the BICZM Belize Integrated Coastal Zone Management Plan (2016), and focuses on Corozal Bay

• Overall objective:
  – “To design and carry out the feasibility studies required for shoreline stabilization measures considering an ecosystem-based adaptation approach for 1 km of the coast of Corozal District”

• Mangrove restoration is a key component of this project
Satellite Based Imagery – World View II and III

• Satellite-based imagery provided data on:
  – Bathymetry and topography
  – Habitat mapping and shoreline morphology
  – Land Use and Land Cover
Satellite Derived Products - Terrain and Bathymetry
Satellite Derived Products – Shoreline Type and Coastal Resources
Satellite Derived Products – Land Use/Land Cover Classifications
Satellite Based Imagery – World View II and III

- This data fed into a coastal modelling exercise and the definition of flooding and erosion risks.
Resilience Priority Areas

- Recommendations were then made for coastal resilience priority areas, targeting support for tourism and economic growth.
- These sites were targeted for Demonstration Projects involving mangrove restoration.
Mangrove Selection

- *Rhizophora mangle* (Red Mangrove) naturally occurring near all sites
- Proposal for Red Mangrove planting, but potential for limited black mangrove to naturally establish at higher elevations
- Nearby source of Red Mangrove propagules (planting and natural recruitment)
- Ideal candidate for sustainable shoreline protection
- Supports a variety of ecosystem services
Propagule Collection

- Propagule release May to August
- Propagules can be collected from the ground, or mature propagules can be picked from the parent plant
- Can be stored for 6 or 7 days in buckets filled with local seawater (refresh water every 2 days)
Substrate and Seedling Growth

- Will grow in range of coastal sediments
- Will grow in aerobic coastal sediments consisting of fine sands to coarse stones and rocks
- Where mangroves have been observed to grow in coarser substrates such as stones, rocks, the roots have likely established in sediment trapped in the voids
Tidal Inundation and Elevations

- Can tolerate being submerged for extended periods and thrives in fully saturated soils
- Protection from significant wave energy required
- Graded to elevations ranging from mean sea level (MSL) to mean high water (MHW)
Mangrove Design Elements

- Small areas of strategically located mangroves to stabilize the shoreline.
- Locations of mangrove features have been sited based on coastal engineering principles to afford protection to the shoreline and to sustainably manage small pocket beaches.
- Root systems combine with the strength of the rock structures and rock fill areas to provide a low-cost resilient and sustainable.
- Rocky substrate mixed with marine sediments and placed in 300 mm layers with intermediate surface layers of local sediment.
- Substrate left to settle and then topped up/trimmed prior to planting.
Mangrove/Boardwalk Demonstration Site – Corozal Town

Mangrove Demonstration Area
Corozal Town – Indicative Cost = $840,150 USD

Additional berthing area (orange shading) to be provided at the pier. Pier constructed of timber supported by timber piles (piles provide fenders).

Localized sections of rock placed seaward of boardwalk to protect the mangrove area. Rock reef structures acting as small breakwaters. Structures up to 1.6m high with 2m crests. Medium/high quality rock with controlled grading.

Concrete repairs to infill voids at foundation of existing concrete seawall. Locally strengthen the repairs with placement of infill rock.

3m wide timber boardwalk (brown shading) superstructure, locally widened to 6m to provide swimming platforms. Boardwalk supported by intermediate concrete foundations (black dots)

Infill rock placement on foreshore at lee of boardwalk to encourage sedimentation, to allow mangroves to be planted and establish. Averaged layer thickness of 1m. Can be wide graded rock fill of low quality.
Typical Cross-Section: Corozal Design
Mangrove/Beach Demonstration Site - Sarteneja

Mangrove Demonstration Area
Sarteneja – Indicative Cost $252,856 USD

- Main pier (concrete)
- Rock structures planted with mangroves (further descriptions below against letters A to D)
- Dilapidated pier (wooden)

480m$^3$ of beach sand nourishment. Average beach slope of 1 in 10 with 4m crest at 0.7m MSL.
Typical Cross-Section – Serteneje Design
Evaluating Benefits of the Designs

- Local recreational use of the improved boardwalk and waterfront
- Increased visits to the waterfront amenities by tourists
- Increased boating traffic to the area with increased mooring capacity
- Protecting coastal roads, footpaths, residences and businesses from erosion and flooding