Various Concepts of the Sustainable Ports

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Borneo International Maritime Week 2025
Oct 2025

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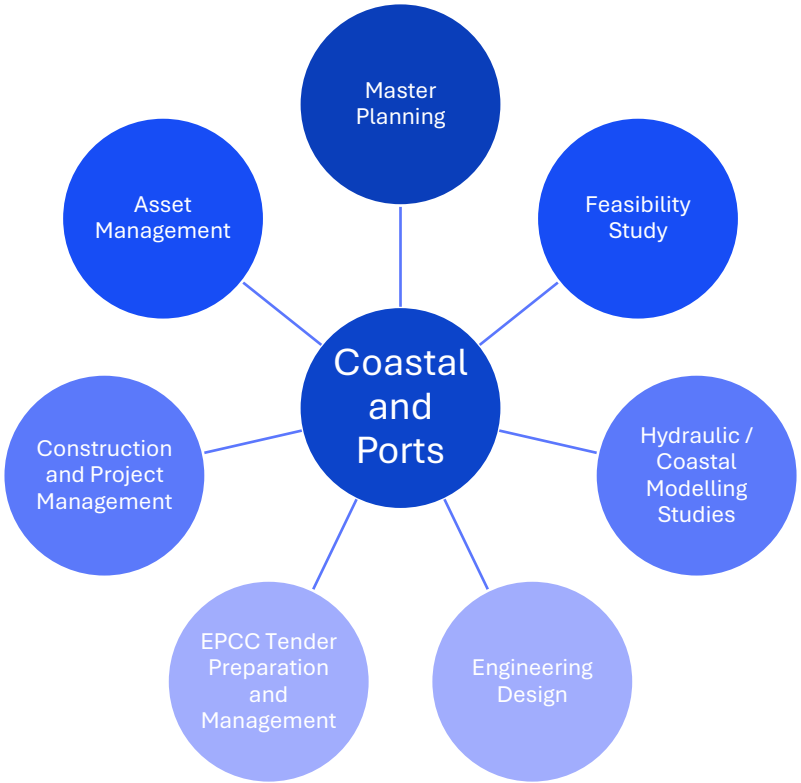
Coastal Engineering and Ports and Maritime,



What is Sustainable Port?

- Adopting Environmental, Economical and Social Sustainability in Port Design, Development & Operations by adopting environmentally compatible designs in constructing resilient infrastructure and adopting best practices to reduce environmental pollution, reduce GHG emissions and restore biodiversity.

- Promotes Port development, operation and maintenance aligning to ’Working with Nature’ concept.

- Adopt Eliminate, Reduce, and Control (ERC) approach

- Monitoring, Improvement and Reporting of the Measures adopted for GHG emissions reduction, socio-economic, biodiversity and environmental protection.

Ways to Sustainable Port development

- Use of Renewable Energy
- Electrification and Digitalization
- Energy Efficiency
- Optimise the operation process
- Economic sustainability
- Environmental sustainability

SJ Track Record on Green Port Projects

Jurong Port – Singapore (2016)

Berths J10 & J11 of Jurong Port are the **1st green berths in the world**.

Green construction methods and materials and environmental sustainability features (**recycled concrete from existing structures at the port**).

Jakarta Integrated Green Terminal (2024)

As a 'Green' Terminal, JIGT has the opportunity to be environmentally-conscious on two main fronts: providing **Green Products** (e.g. Liquid CO2, Used Cooking Oil, Sustainable Aviation Fuel) as well as **Green Operations**.

It will also assist with the **transition away from higher-emissions Coal-fired energy production** by providing facilities for Liquid Natural Gas (LNG).

NBS Initiatives for Sustainable Ports

NBS opportunities are grouped under an NBS Family as follows:

- **Working with Coastal Systems:**
  - NBS emphasize working with natural coastal processes instead of against them. This family focuses on the **interaction between ports and their surrounding (coastal) environment**. Working with coastal systems can lead to **reduced sedimentation issues** within the port and create more favorable conditions for vessels

- **Wave and Coastal Dynamics Attenuation**:
  - Wave disturbances both outside and inside the port basin can impact port efficiency and operations. Therefore, a family of **NBS designed to dampen and protect against waves** is logical. Various ecosystems and natural formations can attenuate waves. NBS in this category, such as vegetated features, **living shorelines, and reefs can reduce wave energy**, dampen wave reflection within a port basin, decrease wave-dominated sediment transport, and/or protect against storm impacts.

Nature Bases Solutions

Rockyshore / Artificial Rock Pools

- Aim: to mimic rock pool / rocky shore like habitat upon the revetment
- Recruitment shown to take 3 months+ in temperate regions (Poole Harbour Initiative)
- Sediment could potentially fill up sheltered pools and fail to function
- Successful Blue-Grey NBS in Penang (Chee et al., 2020)
- Living seawall has been successfully used in SEA (Image A) (https://www.livingseawalls.com.au/)
- Ecosystem services:
    - Supports intertidal biodiversity
    - Dissipates wave action and decreases coastal erosion: this is only likely to be a service where the artificial rockpool habitat sits in front of area needing protection

Wave Dampening

- V-Shape designs which copy the design of a bow of a ship, help to deflect wave energy (Image C) (Hall et al., 2019). Such 'vertipools' are shown to support 5x the amount of biodiversity as a typical seawall after 5 years.
- If fitted onto sea walls or revetments, unlikely to dissipate wave energy unless designs to have V shaped features. If set away from coastal that needs protecting, it will have a benefit.

NBS – Biodiversity Enhancement Tiles

Design Considerations

Placement of biodiversity enhancement tiles - The biodiversity enhancement tiles should be installed in the intertidal zone, between the Mean Low Water (MLW) and Mean High Water (MHW).

Textural and structural complexity - Textural and structural complexity (e.g. grooves, crevices) help to **mimic natural habitats**, providing **shelter and attachment points for other intertidal organisms**.

Choice of material - The material used to construct the biodiversity enhancement tiles should be non-toxic, durable, and resistant to corrosion. Commonly used materials for biodiversity enhancement tiles include **green concrete.**

Future sea level rise - The design should consider the flexibility of the biodiversity enhancement tiles to support subtidal marine organisms in the future as well.

Arc Marine tiles at Cornwall, UK (Photo credit: Cornish Times)

BioBoss tiles at Changi Bay, by the Experimental Marine Ecology Laboratory, National University of Singapore (Photo credit: Stephen Caffyn)

NBS – Oyster Seabed

- For successful establishment, habitat that is >50% inundated is considered suitable for oyster habitat
- Oyster will only colonise **between 2.4-10m depths**
- Utilises recycled oyster shells
- Ecosystem services:
    - Oysters help to filter water
    - Provides habitat for marine wildlife e.g. crustaceans
    - Oyster production – natural recruitment of oysters can help boost local population and benefit local oyster stocks
    - **Protects from coastal erosion**
- Artificial oyster reefs **attenuate wave energy via reflection, overtopping, wave breaking and friction**, thus helping to prevent coastal erosion (van Prooijen, B., et al., 2021)
- Footprint of the reef's affect is limited to the area close to it.
- Reefs were able to dissipate wave energy and act as breakwaters for tidal water levels between 0.5–1.0 m. Waves were totally blocked by the vertical relief of the reefs at water levels <0.5 m (Chowdhury M.S.N et al., 2019). Also **resulted in 54% decrease in erosion compared to control**

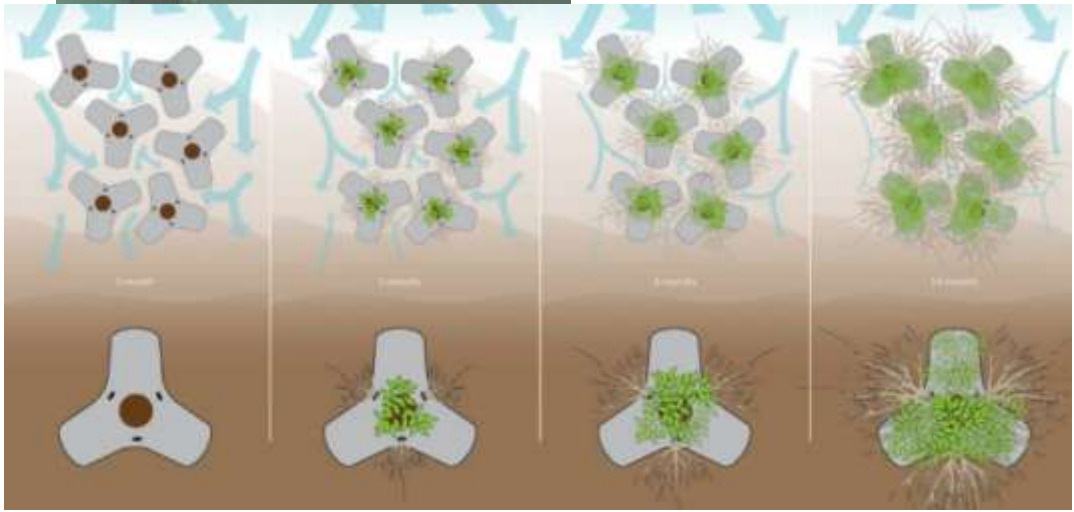
NBS – Perimeter Bunds

Mangrove

- Erosion control – over time, the structures may trap sediment and help build up a shoreline to protect that behind
- Biodiversity – will provide biodiversity value as part of the canopy.
- Wetlands and Mangrove Restoration – Creation of Mangrove Breakwaters in Jakarta Fishing Port, Indonesia has not only restored mangroves but provided an additional buffer to the port where the complexity and density of root, branch, and leaf coverage to provide significant shelter from wind and waves.

Wave Damping

- Physical structure of the planters will help dissipate wave energy as would the trees and roots that establish.
- Given that the habitat would be very narrow, it would not provide the level of dissipation that a naturally occurring mangrove or wider mangrove habitat would provide.



Reference: TetraPOT uses mangroves to grow a greener sea defense system

Key Take Away Points

- Sustainable port is often talked in terms of GHG emissions which is controlled by use of electrification and use of renewable energy from port operation point of view.

- In addition to that, it is also important to consider the green construction method.

- Furthermore, the damage to the environment and local habitats during construction is important to be resorted.

- Nature Based Solution is important to study which will bring benefits on restoring the environment around the port, benefits in providing shelter to the port infrastructure and also help in capturing some of the carbon emissions from the port activities.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