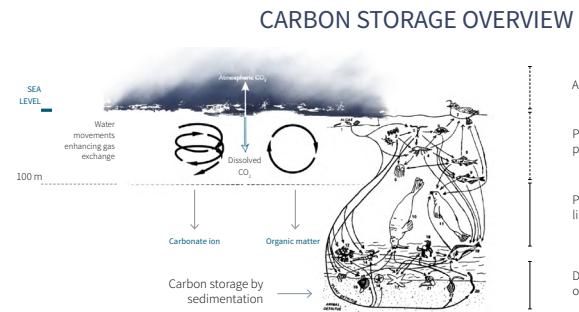


Place-based landscape

Coastal ecosystems are carbon sequester and store more carbon per unit area than terrestrial forest. 83% of the global carbon cycle is circulated through the ocean.

COASTAL HABITAT & CARBON SINK CAPACITY



83%

2%

Global CO₂ circulation in ocean

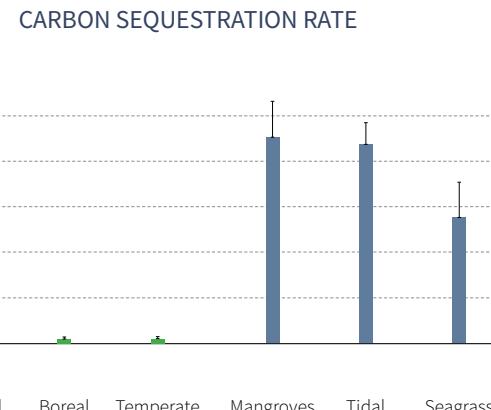
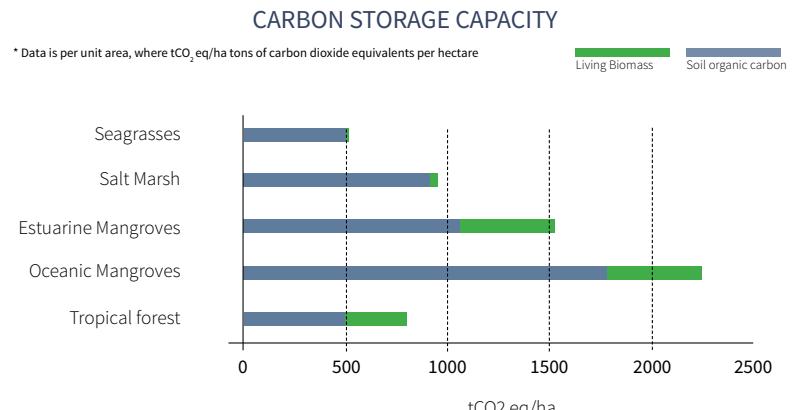
Global coastal area coverage

50%

CO₂ sink in form of sediments

Coastal habitat cover less than 2% of total ocean area, but account for approximately half of the total carbon sequestered in ocean sediments. Posing it as most critical habitat in face of climate change. Aim of this project is to **enable natural processes to shape land and sea, repair damaged ecosystem, restore degraded landscapes and let nature take care of itself.**

It is formulated based on recent understanding of the wildlife conservation approach that when nature is left alone to recover and properly protected - abundant life rebuilds, helping to address the climate emergency by capturing carbon. Through rewilding, wildlife's natural rhythms create wilder, more biodiverse habitats.



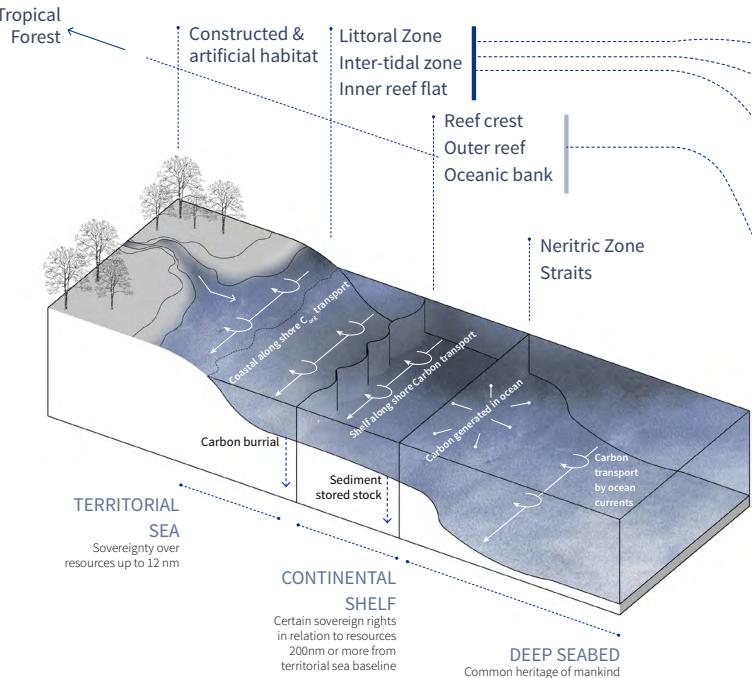
Source // <https://www.iucn.org/resources/issues-briefs/blue-carbon>

Source // Murray, Brian, Limwood Pendleton, WAaron Jenkins, and Samantha Sillett. 2011. Green Payments for Blue Carbon: Economic Incentives for Protecting Threatened Coastal Habitats. Nicholas Institute Report. NI R 11-04

Source // Blue Carbon Initiative with data from McLeod et al., 2011.2

TRANSPORT OF CARBON ACROSS MARINE HABITATS AND BLUE FOREST TYPES IT SUPPORTS

CARBON FLOW IN MARINE HABITATS



BLUE FOREST TYPES

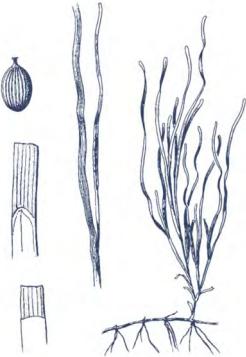


FOCUS - SEAGRASS HABITAT AND SUPPORTIVE SYSTEMS THAT HELP THRIVE SEAGRASS HABITAT

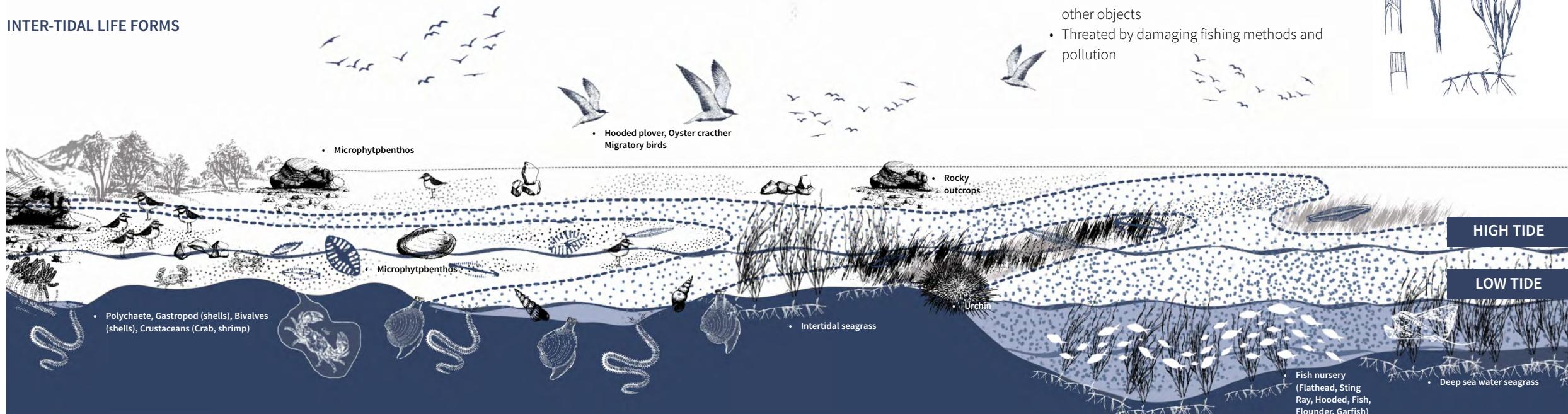
WHAT ARE SEAGRASS?

Seagrasses are the only flowering plants which grow in marine environments. There are about 72 species of fully marine seagrasses and mainly found in bays, estuaries and coastal waters from the mid inter-tidal (shallow) region down to depths of 50 or 60 metres.

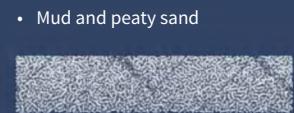
- Seagrass produces flowers, seeds and fruits while seaweed is macro algae
- Uses roots to extract nutrients from sediments while seaweed uses 'hold fasts' to anchor itself to other objects
- Threatened by damaging fishing methods and pollution



INTER-TIDAL LIFE FORMS



INTER-TIDAL SUBSTRATES



- Rocky outcrops

- Sand

- Mud and peaty sand

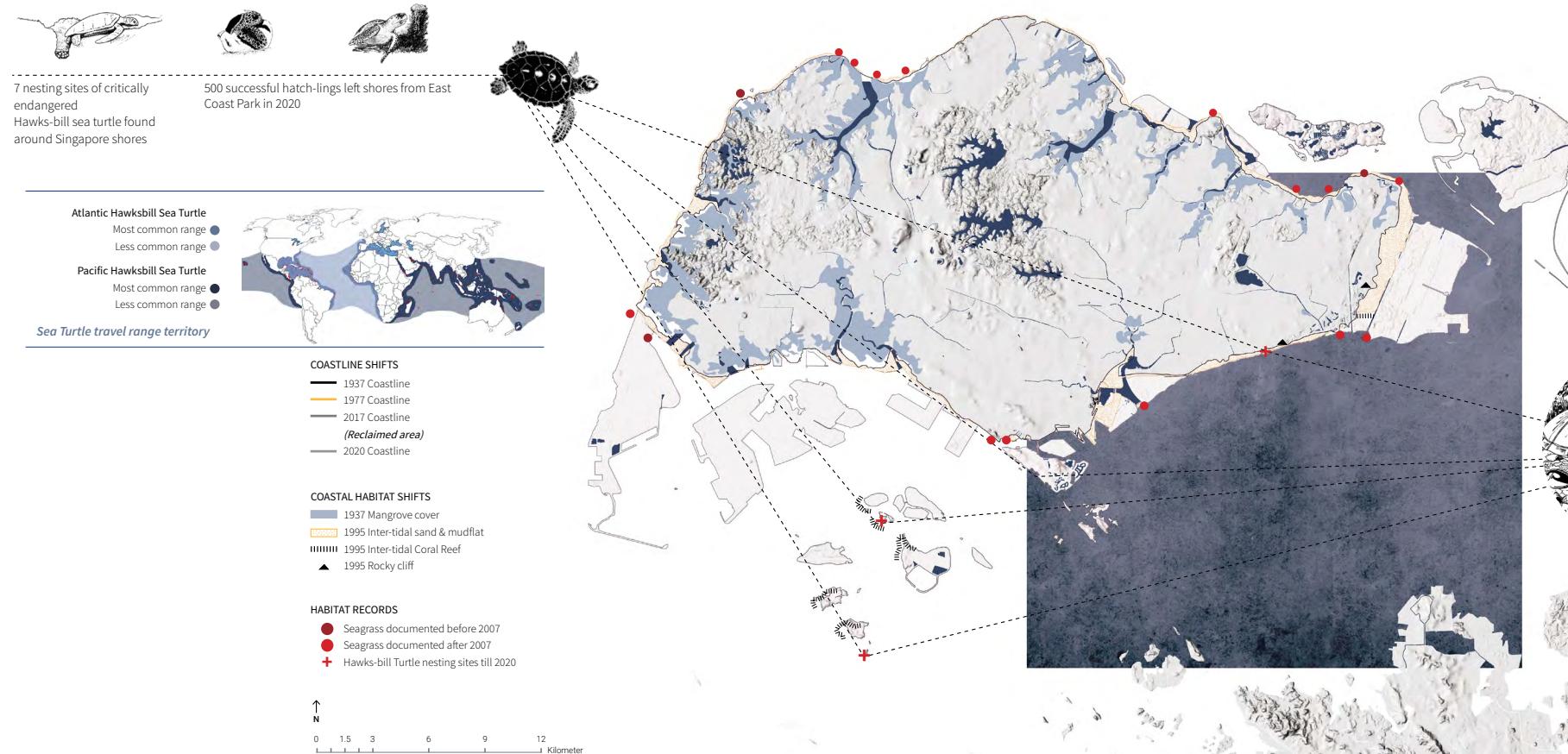
FAVORABLE CONDITION

- Sufficient light
- Inter tidal to max. 70m depth
- Low energy location
- Require soft substratum
- Inundation > 18hr / day

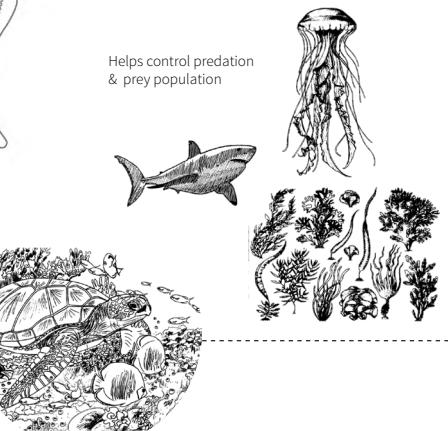
BENEFITS

- BwN and Seagrass : Natural barriers for coastal defense
- Water quality and enhancement
- Wave force reduction
- Limits erosion
- Sediment stabilization

SITE - EAST COAST PARK (ZONE H)



Helps control predation & prey population



Sea turtles grazing on seagrass is an important way to keep seagrass beds healthy.

Nesting helps beaches and ocean to terrestrial nutrient flow. Hatchlings are important source of food for many animals

Critically endangered sea turtle nest sitings at East Coast Park is an indication of ecosystems availability that allows them to thrive there. The coast need to be preserved and protected.

SINGAPORE COASTS, TERRITORIAL SEA BOUNDARY AND BLUE-CARBON SINK OPPORTUNITY

SEAGRASS SPECIES FOUND IN SINGAPORE

SPECIES



*Cymodocea
rotundata*



Enhalus acorides

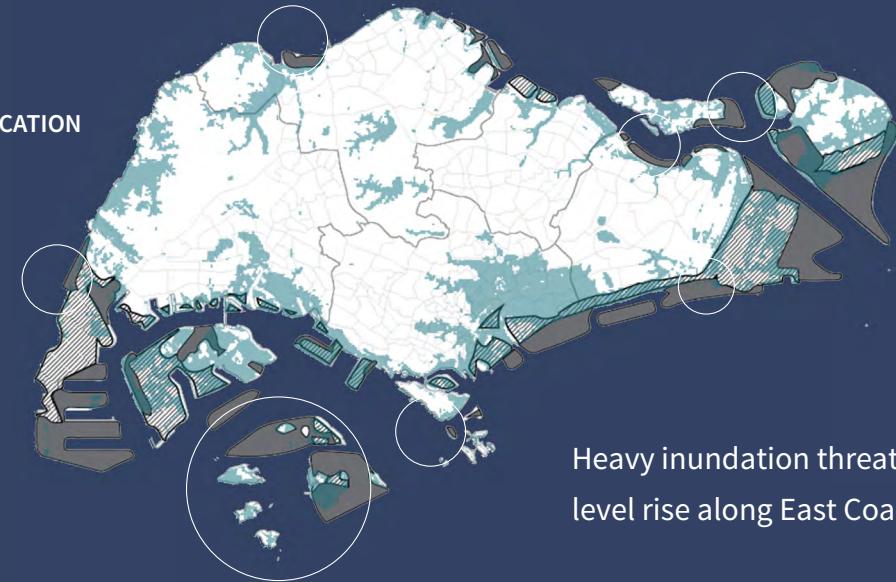


Halodule uninervis



Halodule ovalis

MAJOR LOCATION



Heavy inundation threat from sea level rise along East Coast stretch

SITE TIMELINE

1830

East Coast Salt marsh and Mud flat before 1930s



Approx. 1,735 hectare of vast Sand and mud flat around East Coast till Changi area

1930

Bedok coast line till 1969



Various fishing dwelling across East Coast

East Coast relatively in pristine state till 1969

1970

East Coast land reclamation



Initial plans for land reclamation laid out

1980

2000

2010

2020

Whole East Coast park is built on reclaimed land



High popularity and high visitor influx led to refining zones and access points

Reclaimed land converted into park and became highest visited park

EXISTING CONDITION

ZONES & DOMINANT VEGETATION	Embanked River Bedok & Tanah Merah canal	Park connector and vegetation buffer	Stone breakwaters & Sandy shore	Near shore sea water	Deep sea
 ISSUES <ul style="list-style-type: none">High nutrient loaded run-off pollution leading to increased competition between algae and seagrassLack of appropriate habitat buffer and coastal erosion	 <p><i>Casuarina equisetifolia</i> <i>Terminalia cattappa</i> <i>Terminalia ivorensis</i> <i>Khaya senegalensis</i> <i>Hibiscus tiliaceus</i></p>		 <ul style="list-style-type: none">Fast growing trees preferred on reclaimed land but not appropriate for coasts. This leads to higher rate of erosion	 <ul style="list-style-type: none">Paddling and anchoring affect sea floor and seagrass meadows bed.	
			 <ul style="list-style-type: none">A few years ago, a popular cycle track in this area was closed because of sea was eroding the path. Reclaimed coastline experiencing heavy erosion despite of many break water structures.		

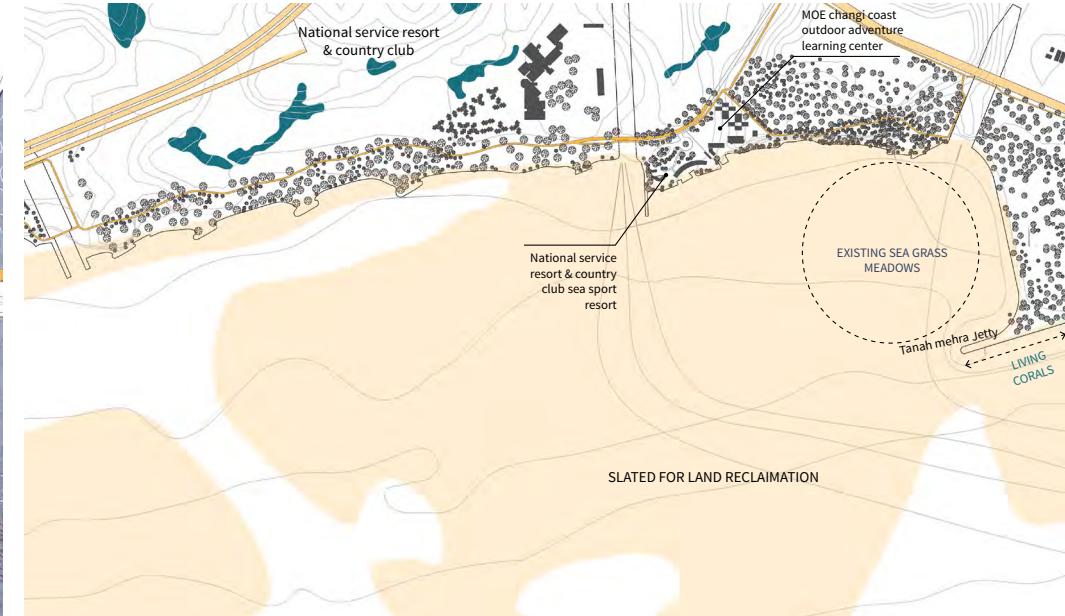
SITE CONTEXT



Nature's way - towards ecosystem recovery

When it comes to rewilding, there is no defined end point for rewilding. The aim is to support nature-driven processes, which in turn will bring about wilder nature. This takes time and space. Rewilding is about moving up a scale of wildness, where every step moving up this scale is seen as progress.

EXISTING - LAND RECLAMATION SLATED FOR HOUSING



SEA LEVEL RISE PROJECTIONS



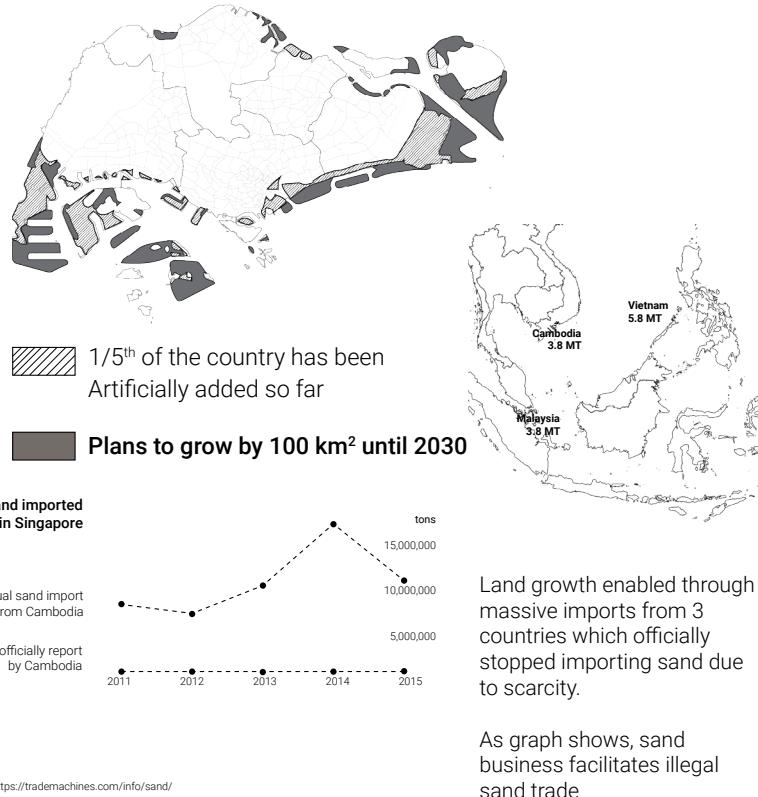
Reclaiming land and building sea wall is a response intended to protect east coast from inundation. The sea gradient being -30m might make it challenging and costlier deal.

Exsiting green spaces & urban fabric

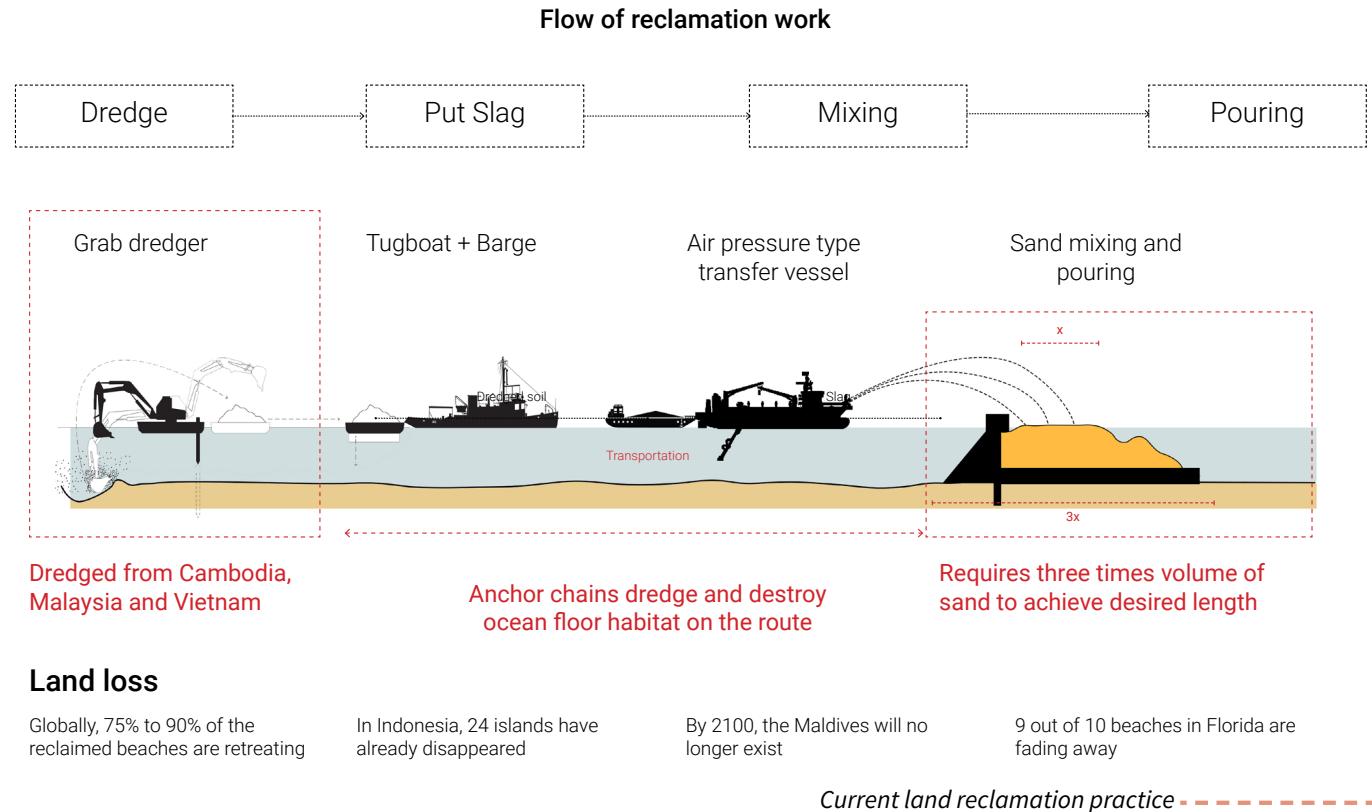
2 degree warming projection

4 degree warming projection

SINGAPORE NEEDS SAND TO EXPAND ITS TERRITORY



COST OF SAND MINING AND LAND RECLAMATION FOR OFFSHORE SEAWALL



Proposed alternative - - - - -

ALTERNATIVES TO SAND FOR RECLAMATION PURPOSE

Materials and procurement methods



1 Recycled concrete

Procured from demolished buildings and phased out projects

↑ Bigger particles can be used with concrete



2 Recycled glass

Crushed bottles and glass, needs material recycling infrastructure in place



3 Clay from earthwork

Procured from underground construction work in Singapore

Smaller particles can be reused for glass

Benefits

Appropriate for using as sub-base

Proven to be strong as sand concrete, Saves up to 14% costs, Reduce CO₂ emissions by 18%

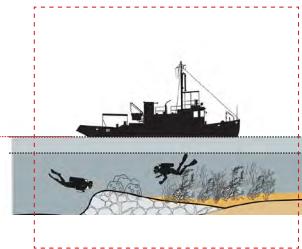
The process to make uncooked clay as solid as concrete was recently patented, 20times less CO₂ emissions, Less expensive

ALTERNATIVES TO LAND RECLAMATION TO PROTECT EAST COAST

Living sea wall

Drop stones and fix sea-wall units manually

Highest astronomical tide
Tidal range



Partially submerged near-shore break water

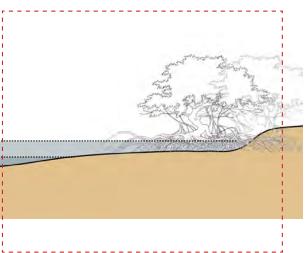
Shallow clear water

Sand/mud deposition

Let mud/sand particles deposit itself

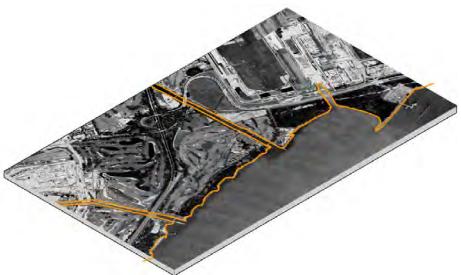
Inter-tidal sand/mud flat & Eco-shoreline

Shore line with different kind of accessibility



Partially submerged near-shore break water

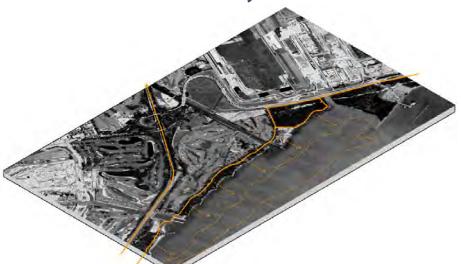
CONCEPT



Sharp fresh-salt water transition and high salinity gradient



Seagrass meadows decline, corals under threat

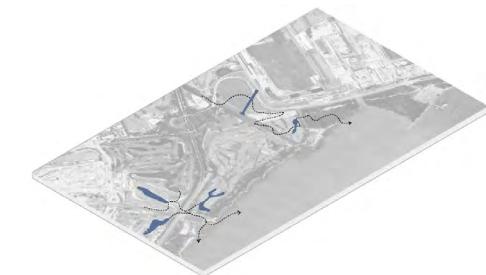


“Out of sight, out of mind” attitude to coast

MASTER PLAN

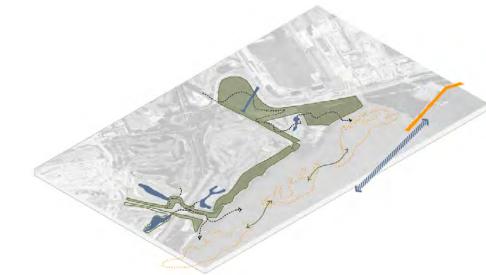


OBJECTIVE



Restore tidal dynamics and facilitating sediment deposition

Restoring fresh-salt transitions with diverted streams that meet the coast in wetland zones enhances and diversifies habitat conditions. Introducing gradients creates opportunities for flora and fauna with varying salinity tolerances, from migrating fish to plant ecosystems.



Three-fold habitat restoration effort

- 1 Protect existing seagrass meadows and coral reef.
- 2 Restore mangrove, seagrass and coral reef. Attempt is to extend and enhance existing habitat to grow full scale under water garden
- 3 Enhancing economic opportunities of organizations that plays vital role in restoration effort



Urban engagement

Emotional connectedness to nature is a significant predictor of nature-protective behavior. Urban disengagement with nature and living in sterilized environment has drastically affected nature conservation efforts. Attempt is to bridge this gap and provisions for intimate experiences of life below sea level.



FUTURE - PROJECT PHASING

Planning

2025

Restoration phase

2030

Base forest ready

2035

20 years young
mature habitat

2040

3 FOLD RESTORATION PHASING

With growth rates of 0.3 to 2 centimeters per year for massive corals, and up to 10 centimeters per year for branching corals, it can take up to 10,000 years for a coral reef to form from a group of larvae. Depending on their size, barrier reefs and atolls can take from 100,000 to 30,000,000 years to fully form.

Corals

Germination cycle

10 cm per year



Involving people

Need experienced divers for Coral larva collection

Small seagrass species, such as *Zostera noltii*, produce new leaves much faster (13.71 days) than species with large leaves, such as *Posidonia oceanica* (50.68 days). Roots are typically formed in the inter nodes of rhizomes, both horizontal and vertical.

Seagrass

15 days to 50 days for healthy meadows restoration



Seed dispersal can be integrated with recreation

It takes 10-15 years for a mangrove tree to reach maturity. For the first 5 years of its life, WWF, with the help of local communities will care for your tree to make sure it stays strong and healthy. At five years old it will be big and strong enough to be 'independent'.

Mangroves

10-15 years till maturity



Once tidal function is restored, mangroves are planted

Submerged off-shore break water barrier

Larva collected from corals are grown offshore and replanted in reef balls after sufficient growth results offshore

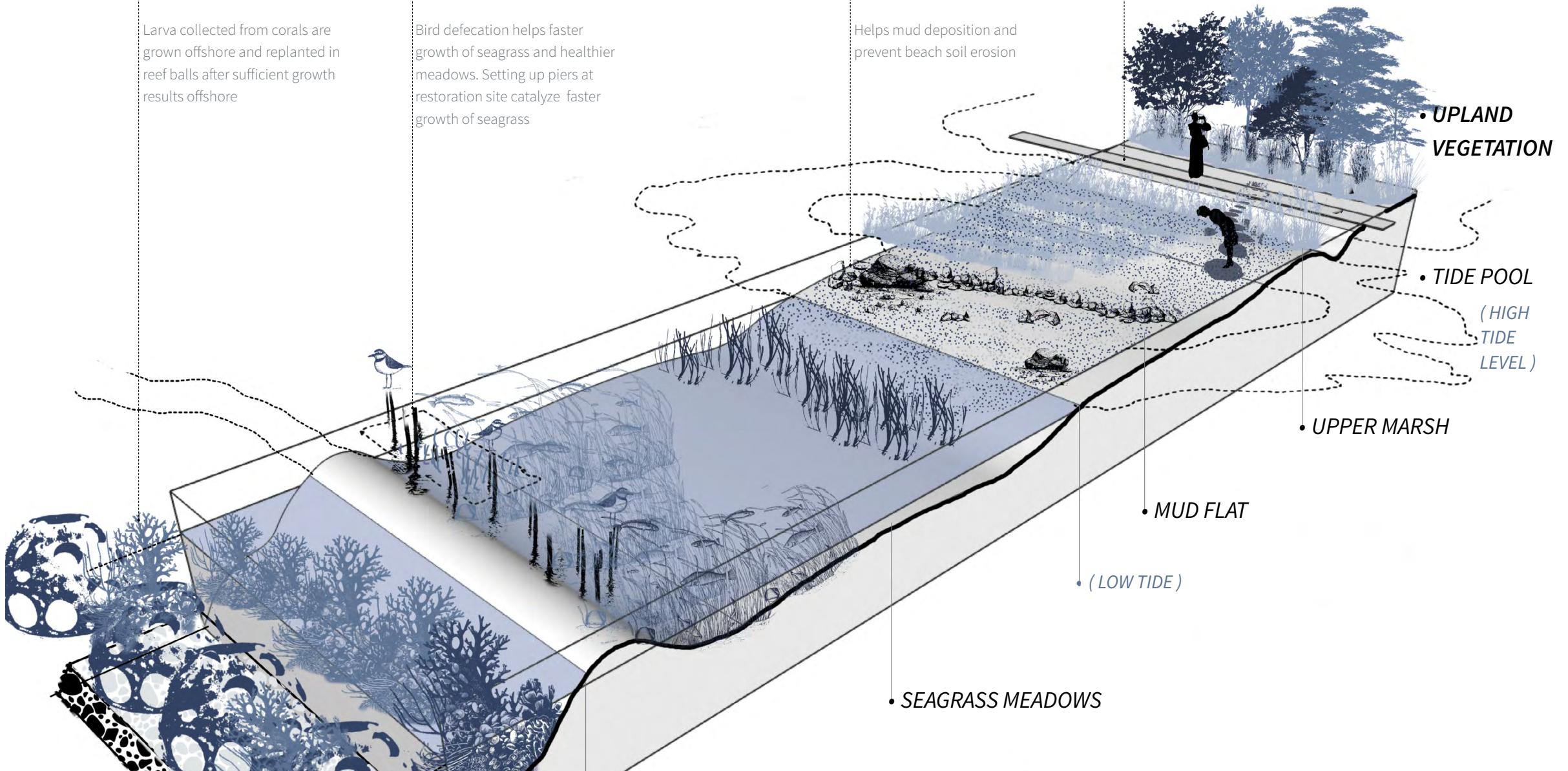
Submerged Piers

Bird defecation helps faster growth of seagrass and healthier meadows. Setting up piers at restoration site catalyze faster growth of seagrass

Oyster shell barrier

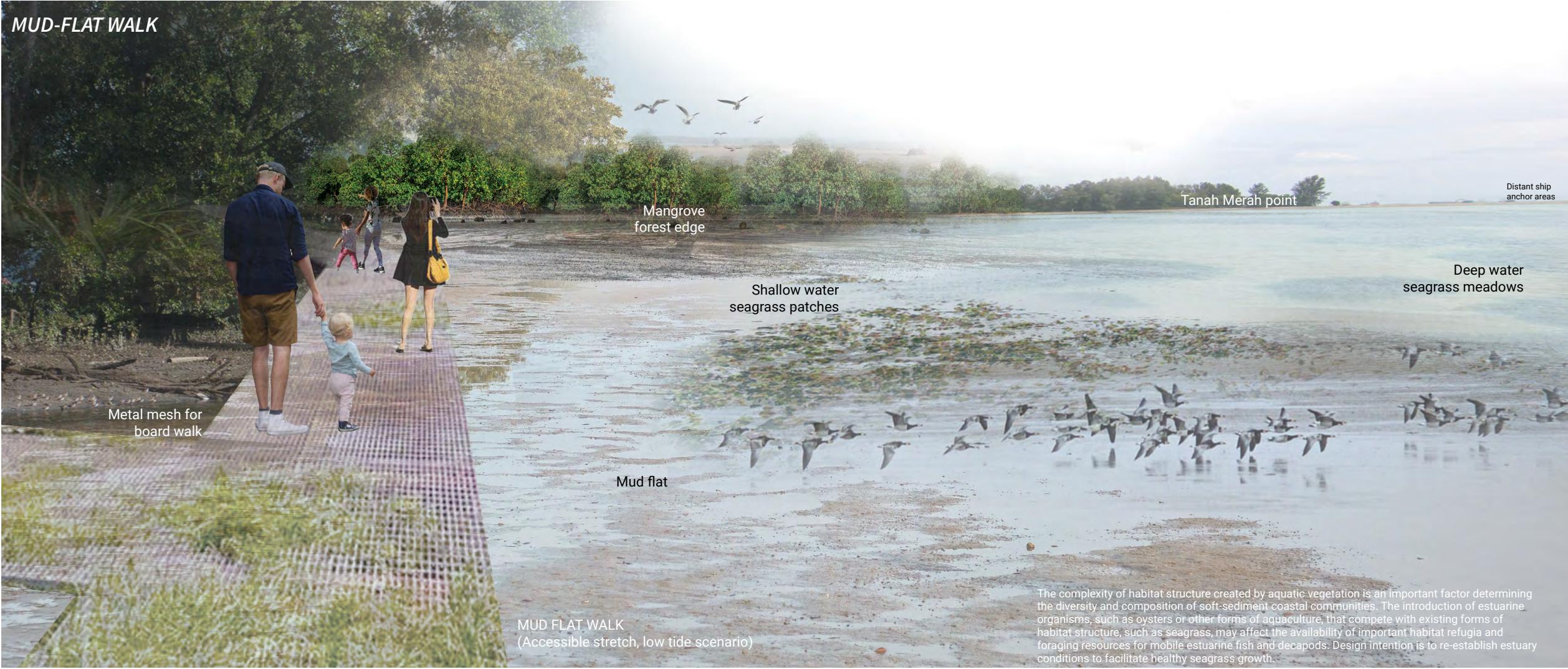
Helps mud deposition and prevent beach soil erosion

Curated access to each zone





MUD-FLAT WALK



UNDERWATER GARDEN

