Pulau Semakau Landfill – A Haven For Coastal And Marine Biodiversity

The pressure to manage its solid waste and the lack of land led to Singapore's decision to develop the world's first offshore landfill. Development considerations included minimising impacts to biodiversity. Today, it is not only a landfill, but also a coastal and marine biodiversity haven. With the way forward, it can be featured as an illustration of sustainable development which addresses many of the United Nations Sustainable Development Goals.

Lim Tian Kuay
National Environment Agency

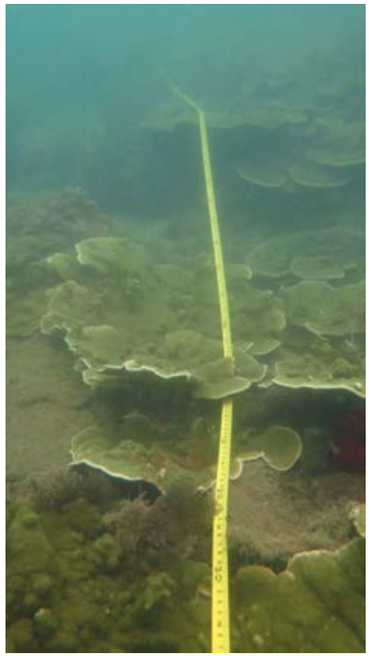
L.M. Chou
National University of Singapore

The 350-hectare Semakau Landfill, the first offshore landfill in the world, received the 2019 Hassib J. Sabbagh Award for Engineering Construction Excellence on 23 November 2019. It was quite coincidental that Semakau Landfill won the engineering award for its outstanding engineering feat twenty years after its completion in 1999. A seven-kilometre rock bund demarcated 350 hectares of the sea linked to two islands that were previously inhabited. The larger is Pulau Semakau endowed with rich coastal and marine habitats including mangroves, coral reefs and seagrass beds. Reclaimed from the sea, the landfill area is demarcated by a perimeter bund within which, cells were progressively emptied off seawater and filled with incinerated ash.

Saving The Mangroves and Coral Reefs on and Around Pulau Semakau

It is lesser-known that during the physical development of Pulau Semakau, measures were taken to minimise environmental impacts and to safeguard and enhance the natural ecosystems, like mangroves and coral reefs. Firstly, to make up for the loss of 13.6 hectares of mangroves that had to be destroyed during the development, Professor Leo Tan and the late Professor Lee Sing Kong advised on the replanting of mangroves at alternative sites. This was a major undertaking at a time when mangrove restoration was not that well understood. Secondly, Professor Chou Loke Ming proposed the use of fine mesh silt screens to prevent sediment generated by the perimeter bund construction from spilling over to the coral reef and seagrass bed on the island's western coast.

These measures were implemented as part of the Environmental Impact Assessment to mitigate adverse effects on Pulau Semakau's coastal and marine habitats. The coral reef was monitored over the three years it took for the construction of the perimeter bund. Permanent transect lines and quadrat plots were established and surveyed to assess reef condition [see Figure 1]. The results indicated minimal impact to the reef with live coral cover remaining intact throughout the development.



01 Line transect deployed to measure reef condition.

Biodiversity of Pulau Semakau

At least five different types of ecosystems are found at Pulau Semakau, a testimony of its rich and diverse biodiversity. The ecosystems represented on both the landfill site and the more natural areas are:

1. Grass- and scrubland on the filled cells

a. Many coastal pioneer plant species like casuarinas now thrive on the island.

b. Wildflowers are widespread.

c. Many bird species, both resident and migratory species like the Great-billed Heron, Grey Heron, Large-tailed Nightjar, Barn Swallow, Pacific Swallow, Kingfisher, Changeable Hawk Eagle, Malaysian Plover, Pacific Golden Plover, etc., have been sighted.

d. Many arthropod species like bees, butterflies, beetles, dragonflies, etc. are present.

e. Marine life including hard corals, algae, and fishes have been observed in the unfilled cells currently holding seawater.

02 An aerial view of replanted mangrove at the Northern plot of Semakau Landfill.
03 Replanted mangrove at the Southern plot of Semakau Landfill.
04 Seagrass and macroalgae on reef flat.
05 Intertidal reef flat at west of Semakau with mangroves in the background.
06 Coral with laminate growth form.

02

03

04

05

2) Mangrove forests [*Figure 2 and Figure 3*]

a. Apart from the natural mangroves on the western shore from which 13.6 hectares were lost, two other sites of replanted mangroves north and south of the natural mangroves now thrive. Based on a novel plan by Professor Leo Tan and the late Professor Lee Sing Kong, then respectively the Director and Head of Biology at the National Institute of Education, the replanting of mangroves compensated for the loss of mature mangroves as a result of the decision to anchor the perimeter bund to the eastern shore of Semakau. The replanted mangroves are now teeming with biodiversity like the natural mangrove and continue to provide ecosystem services such as shore protection and coastal erosion prevention.

b. Diverse mangrove trees like Avicennia spp., Rhizophora spp., are present.

c. Snails, crabs, spiders, reptiles and amphibians, found in abundance add to the rich mangrove habitat biodiversity.

3) Seagrass meadows [*Figure 4*]

a. Seven seagrass species have been recorded in the waters of Pulau Semakau. Making seagrass meadows their home is a diverse assemblage of animals including fish, crabs, sea cucumbers, sea urchins, sea slugs, etc.

b. TeamSeagrass, an active group of volunteers who collaborate with NParks and a global research programme, Seagrass-Watch, monitors the species and health of the seagrasses periodically.

4) Inter-tidal zone of mud, sand and rubble [*Figure 5*]

a. This area is rich with Knobby Sea Stars, Common Sea Stars, crabs, flatworms, sea anemones, shrimps, sponges, jellyfish, etc.

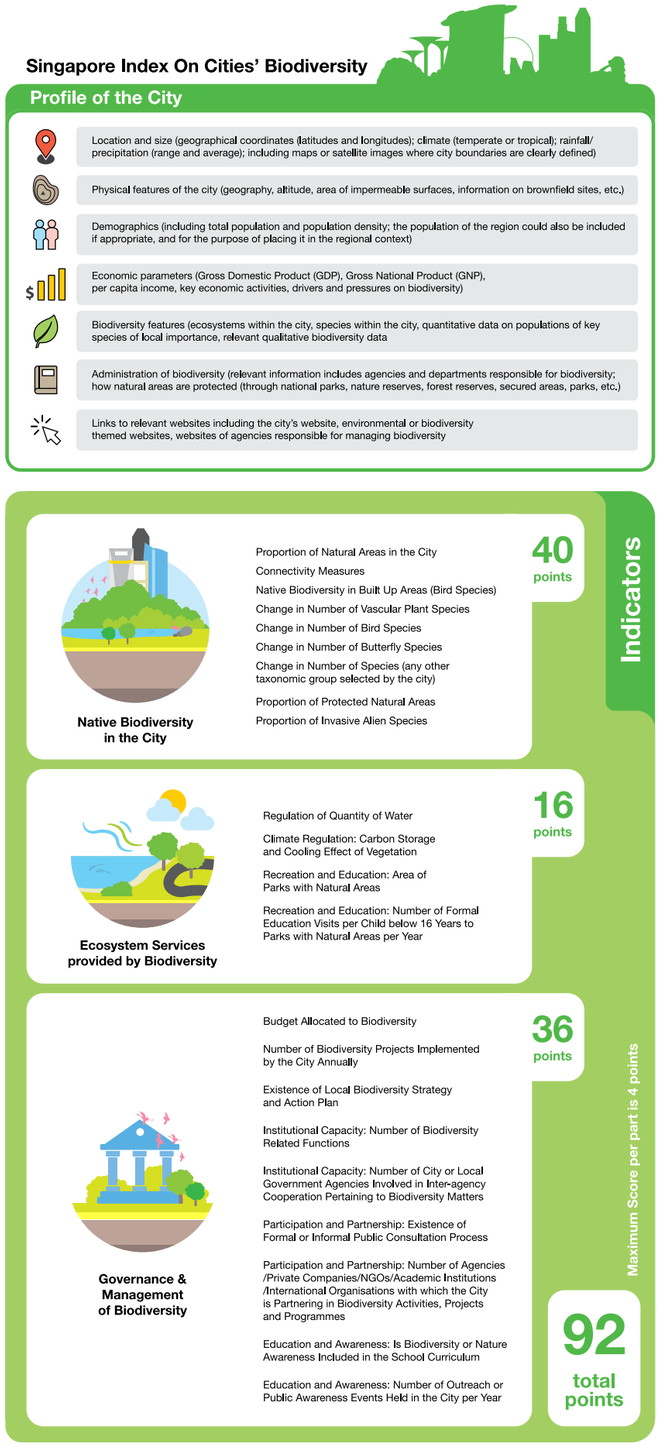
5) Coral reefs [*Figure 6*]

a. Coral reefs are the marine equivalent of terrestrial tropical rainforests. They rival in biodiversity. Coral reefs are vital for human survival as they harbour many species that are valued seafood.

b. Coral reefs also serve a protective function for the coasts.

c. Many species are colourful and much sought after in the marine aquarium trade. Sea fans or gorgonians are spectacular branching species on which tiny gobies, cowries, shrimps and sea anemones, find shelter.

06



07

Way Forward

Monitoring of Pulau Semakau's seawater quality showed no indication of deterioration. This allowed biodiversity to thrive and in turn the rich biodiversity can help to keep the water clean by locking pollutants and sediment. At the same time, the clean environment can support other activities. A floating fish farm has been operating just off Semakau's western reef and a fish hatchery on the island draws seawater not far away from the landing site of barges transporting incinerated waste. Singapore's first coral nursery was launched by the National Parks Board (NParks) in 2007 at Pulau Semakau. Coral fragments are grown in the nursery to a certain size before transplanting back to coral reefs in restoration and enhancement efforts.

The way forward is to continue and strengthen the collaboration with agencies such as NParks on biodiversity conservation as the drive towards a Zero Waste Nation is also synergistic with biodiversity conservation for the following reasons:

1. If there is zero waste, then there will be lesser need for the expansion of Pulau Semakau as a landfill, therefore, there will be more land and sea for Singapore's native plants and animals.

2. If there is zero waste, then there will be lesser pollutants including plastic that will be contaminating the land, freshwater bodies, coastline and seas.

3. If there is zero waste, less energy will be used in treatment, hence, less carbon emissions.

Such initiatives will address many of the United Nations Sustainable Development Goals. Since there is rich biodiversity on and around Pulau Semakau, efforts should be made to track and develop the existing biodiversity, using relevant indicators and as well the underpinning principles from existing monitoring tools and science-based approach like the Singapore Index on Cities' Biodiversity [*Figure 7*]. It would be beneficial and appropriate for relevant agencies such as NEA and NParks to collaborate and lay the groundwork on monitoring and developing the biodiversity of Pulau Semakau for the benefit of generations to come.

The Semakau landfill is transforming sea into land using incinerated waste, and it is done with due consideration to biodiversity enhancement and environmental quality maintenance. We soon have to deal with the challenge of climate change. What is the future of the landfill with rising sea levels? Raising the bund will increase the capacity of the landfill to receive more incinerated waste but can it be done in ways that do not reduce biodiversity but promote it instead?

The expertise of academics could be tapped. There is a growing core of amateur naturalists, non-governmental organisations, photographers and citizen scientists who are interested in biodiversity, environmental issues and climate change. Everyone can play a part to maintain the health and vibrancy of our natural environment.