COASTAL ZONE MANAGEMENT

MANGROVES

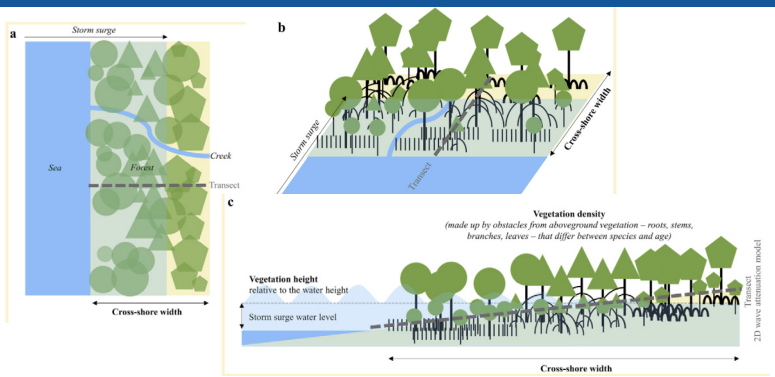
CZM7

NATURE-DEMO

WWW. NATURE-DEMO.EU/

ADDRESSED HAZARDS

PROTECTED CRITICAL INFRASTRUCTURE



Simplified overview of key mangrove properties for wave attenuation, shown in a top-down view (a), a three-dimensional frontal view (b), and a cross-shore side view (c). Image Credit: [Van Hespen et al., 2023]. CC BY-NC-ND Licence.

Mangrove forest at low tide. Image Credit: [David Clode, Unsplash], [2021]. Free to use.

What is it?

Mangroves are coastal ecosystems found in tropical and subtropical regions. They are characterised by salt-tolerant trees and shrubs that thrive in intertidal zones where land and sea meet. Their dense root systems play a critical role in stabilising shorelines, supporting marine biodiversity, and providing ecosystem services such as carbon storage, water filtration, and natural protection against coastal hazards (Kathiresan & Bingham, 2001; Barbier et al., 2011).

Challenges this NbS addresses

- **Floods –** reduction/recovery: by attenuating storm surges and reducing floodwater velocity through dense root structures.
- **Erosion –** prevention/reduction: by stabilising coastal sediments and buffering wave energy.
- **Heatwaves –** reduction: by providing canopy cover that contributes to localised cooling and microclimate regulation.
- **Drought –** recovery: by supporting hydrological balance and maintaining coastal water tables.
- **Windbreak –** reduction: by serving as natural wind barriers that reduce wind speed and protect inland areas.

Primary functions and key services

- **Storm surge attenuation:** mangroves absorb and dissipate the energy of storm surges via their dense root system, reducing the height and speed of waves. This mitigates the risk of flooding for more than 15 million people annually (Menéndez et al., 2020). This NbS Typology enhances the protection of critical infrastructure from flooding such as urban fabric, including **housing** and **basic building services**, **transportation systems** and the good functioning and integrity of **conventional drainage systems**.
- **Erosion control:** their extensive root systems stabilise coastal soils, preventing erosion that can undermine **buildings, seawalls**, and other infrastructure (Pennings et al., 2021).
- **Temperature regulation:** mangroves provide shade and mitigate local heat effects (Abd El-Hamid et al., 2022), which can benefit infrastructure like **pipelines, storage facilities**, or **urban coastal developments** by reducing heat stress.
- **Windbreak:** the dense canopy of mangroves reduces wind speed and impact, particularly during cyclones, protecting structures like **transmission lines** and **communication towers**. (Das and Crépin, 2013).

Site suitability, scale and coverage

Mangrove restoration needs to involve a number of considerations both in site selection and management.

Mangroves restoration is best suited in coastal areas that can be sheltered from extreme climate events, and have structures strong enough to withstand storms (UNEP, 2024). Considerations need to include sites with optimal climate, environmental and soil conditions (UNEP, 2024). Projects may also require that invasive species be cleared in advance and the soil may need to be conditioned.

And successful restoration has been found to require collaboration with local communities. (UNEP, 2024; Iftekhar and Takama, 2007)

Main components

- **Trees and shrubs:** mangroves are composed of salt-tolerant trees and shrubs growing in the intertidal zone.
- **Aerial roots:** mangroves have a dense system of aerial roots that can trap sediments and reduce the energy of incoming waves.

Other technical considerations for the design, implementation, operation and management of the system:

- **Timing** is very important as mangroves can only be planted during low tide (UNEP, 2024).
- Poor **management**, such as illicit felling, has been identified among the main causes of degradation. (Iftekhar and Takama, 2008)

Environmental impacts (EU taxonomy)

- ☑ **Climate change mitigation**
- ☑ **Climate change adaptation**
- ☑ **Sustainable use and protection of water and marine resources**
- ☐ **Transition to a circular economy**
- ☑ **Pollution prevention and control**
- ☑ **Protection and restoration of biodiversity and ecosystems.**

COASTAL ZONE MANAGEMENT

MANGROVES

CZM7

NATURE-DEMO

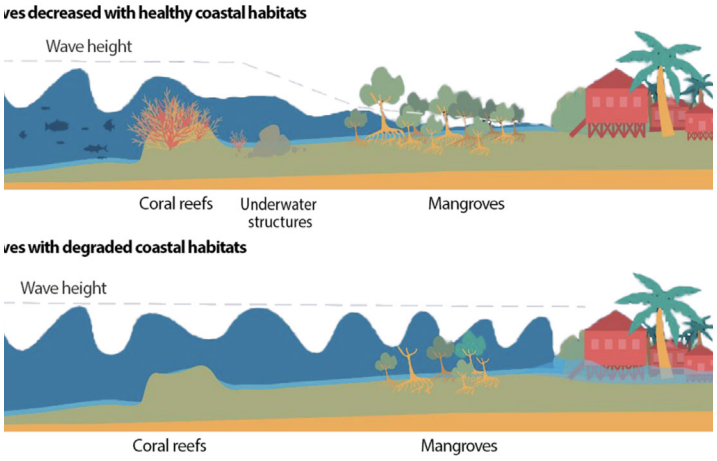
WWW. NATURE-DEMO.EU/

Cost-benefit profile

The costs of mangrove restoration vary significantly depending on site-specific factors such as suitability, accessibility, size, and location. Per hectare, restoration costs range from **$23 to $1,269 (median)**, with **a mean of $209,312** across 20 studies (Su et al., 2021, USD 2019). Breakdown of mean costs includes: **$63,757 for engineering, $23,712 for labour, $9,627 for plantation, $6,747 for maintenance**, and **$24 for transport** (Su et al., 2021). Another review by Bayraktarov et al. (2016) found mean costs of **$8,961** and average costs of **$62,689** per hectare (USD 2010), with higher figures observed in developed countries.

Despite high costs, mangroves offer substantial **benefits**. Coastal protection alone has a net present value of **$8,966–$10,821 per hectare**, while **erosion control** is valued at **$3,679/ha/year**, and **enhanced fishery production** at **$708–$987/ha** (Barbier et al., 2011). They also support livelihoods—valued at **$1,000–$12,000/ha/year** (Hernández-Blanco et al., 2021)—and contribute to **carbon sequestration**, with an estimated value of **$30.50/ha/year** (Barbier et al., 2011). Broader ecosystem service values are reported in Himes-Cornell et al. (2018).

Beyond economics, mangroves are vital for **biodiversity**, providing habitat for fish nurseries and migratory birds (UNEP, 2024). They also enhance **climate regulation, water quality**, and **disaster resilience**, reduce recovery costs, retain soil, and offer **raw materials and cultural services** (Iftekhar & Takama, 2008).



How Ecosystems Protect Communities From Coastal Flooding
Image Credit: [United Nations Environmental Programme], [2024] Free to use.

Ecosystem services

(Barbier et al., 2011; Bimrah et al., 2022)

- **Carbon sequestration:** mangroves capture CO_2, storing large amounts of carbon in biomass and waterlogged soils (Alongi, 2014).
- **Biodiversity Support:** mangroves provide habitat for a diverse range of terrestrial and marine species, enhancing biodiversity.
- **Sustainable Livelihoods:** mangroves support fisheries and other coastal livelihoods, benefiting local communities.
- **Water purification:** by trapping sediments, nutrients, and pollutants in their root system, mangroves can improve water quality.
- **Climate regulation:** mangroves can influence local microclimates, cooling surrounding areas and stabilising atmospheric conditions.
- **Recreation and Tourism:** mangroves are popular destinations for ecotourism like birdwatching, and nature tours.
- **Air quality regulation:** mangrove trees can absorb airborne pollutants.
- **Sense of place:** mangroves can provide cultural identity for coastal communities

Example of installation

- **Restoring Climate-resilient Mangroves and Communities (UNEP, 2024)**
- **Location:** Djibouti, Nairobi
- **Implemented by:** The United Nations Environment Programme (UNEP) and Ministry of Environment and Sustainable Development, Djibouti
- **Description and results:** Project Interventions:

  - Mangrove dredging and replanting with community support
  - Create vegetated buffer areas with salt-tolerant species
  - Examine the potential for alternative energy at community level
  - Acquire equipment and training for sustainable fisheries in mangroves
  - Develop community-based mangrove management
  - Train private sector partners and regional council on ecotourism initiatives
  - Establish nurseries and mangrove planting
  - Increase local communities' awareness and ability to protect restored ecosystems
  - Provide training for climate-resilient livelihoods

Lessons Learned:

- Choose optimal restoration sites and weatherproof them to overcome biophysical challenges.
- Restore using grey-green technologies for adaptation in coastal zones.
- Get the timing right and improve baselines for projects.
- Work with local communities and co-design sustainable long-term solutions.

References

Abd El-Hamid, H.T., Arshad, M. & Eid, E.M. The effects of coastal development on the urban heat island in the mangrove ecosystem along the Jazan coast, KSA. J Coast Conserv 26, 70 (2022). https://doi.org/10.1007/s11852-022-00915-x.

Alongi, D. M. (2008). Mangrove forests: resilience, protection from tsunamis, and responses to global climate change. Estuarine, coastal and shelf science, 76(1), 1-13.

Alongi, D. M., (2014). Carbon sequestration in mangrove forests. Carbon Management, 3(3):313-322 DOI: 10.4155/cmt.12.20

Barbier, E. B., Hacker, S. D., Kennedy, C., Koch, E. W., Stier, A. C., & Silliman, B. R. (2011). The value of estuarine and coastal ecosystem services. Ecological monographs, 81(2), 169-193.

Bayraktarov, E., Saunders, M. I., Abdullah, S., Mills, M., Beher, J., Possingham, H. P., ... & Lovelock, C. E. (2016). The cost and feasibility of marine coastal restoration. Ecological applications, 26(4), 1055-1074.

Bimrah, K., Dasgupta, R., Hashimoto, S., Saizen, I., & Dhyani, S. (2022). Ecosystem services of mangroves: A systematic review and synthesis of contemporary scientific literature. Sustainability, 14(19), 12051.

Clode, D. (2021) The weird roots of a mangrove forest, Cape Tribulation Beach, Australia. Retrieved from: https://unsplash.com/photos/a-bunch-of-trees-that-are-in-the-dirt-8STsYZimS9s (accessed 01.04.2025)

Das, S., & Crépin, A. S. (2013). Mangroves can provide protection against wind damage during storms. Estuarine, Coastal and Shelf Science, 134, 98-107. https://doi.org/10.1016/j.ecss.2013.09.021

Iftekhar, S., & Takama, T. (2008). Perceptions of biodiversity, environmental services, and conservation of planted mangroves: A case study on Nijhum Dwip Island, Bangladesh. Wetlands Ecology and Management, 16(2), 119–137. https://doi.org/10.1007/s11273-007-9060-8

Hernández-Blanco, M., Costanza. R., Cifuentes-Jara, M. (2021) Economic valuation of the ecosystem services provided by the mangroves of the Gulf of Nicoya using a hybrid methodology. Ecosystem Services, 49. https://doi.org/10.1016/j.ecoser.2021.101258

Himes-Cornell, A., Grose, S. O., & Pendleton, L. (2018). Mangrove ecosystem service values and methodological approaches to valuation: where do we stand?. Frontiers in Marine Science, 5, 376.

Kathiresan, K., & Bingham, B. L. (2001). Biology of mangroves and mangrove ecosystems.

Menéndez, P., Losada, I.J., Torres-Ortega, S. et al. The Global Flood Protection Benefits of Mangroves. Sci Rep 10, 4404 (2020). https://doi.org/10.1038/s41598-020-61136-6

Pennings, S. C., Glazner, R. M., Hughes, Z. J., Kominoski, J. S., & Armitage, A. R. (2021). Effects of mangrove cover on coastal erosion during a hurricane in Texas, USA. https://doi.org/10.1002/ecy.3309

Su, J., Friess, D. A., & Gasparatos, A. (2021). A meta-analysis of the ecological and economic outcomes of mangrove restoration. Nature communications, 12(1), 5050.

United Nations Environment Programme (UNEP). (2024). Restoring Climate-resilient Mangroves and Communities: A case study from Djibouti. Nairobi.

Van Hespen, R., Hu, Z., Borsje, B., De Dominicis, M., Friess, D. A., Jevrejeva, S., ... & Bouma, T. J. (2023). Mangrove forests as a nature-based solution for coastal flood protection: Biophysical and ecological considerations. Water Science and Engineering, 16(1), 1-13.