



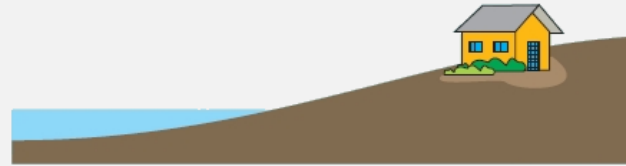
Coastal erosion - mitigation and adaption

Sylfest Glimsdal and Carl B. Harbitz

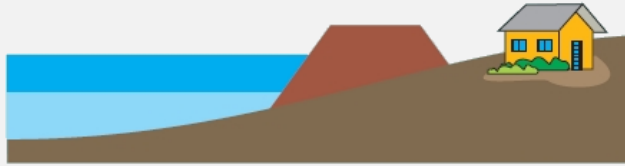
Bilateral Workshop on Disaster Risk Mitigation for the state of Kerala; *October 17-21, 2023*



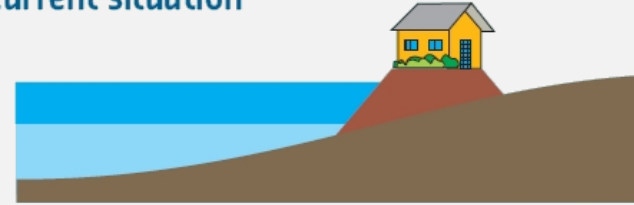
Coastal defence strategies



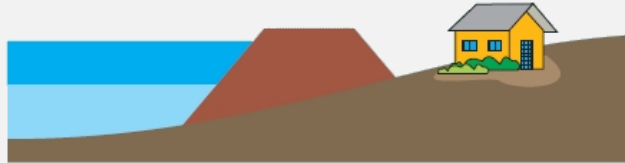
current situation



defence



adaptation



advancement



retreat

E080617g

Source: FLOODsite (2009)

Grey and green mitigation strategies

- Grey mitigation strategies rely on engineered structures and hard materials to provide immediate protection
 - may have higher environmental costs and limited long-term effectiveness.
- Green mitigation strategies emphasize the use of natural processes and ecosystems to protect coastlines and mitigate erosion
 - emphasis on sustainability and minimal environmental impact
- The choice between green and grey solutions often depends on the specific circumstances, goals, and trade-offs in a given coastal protection project
- Best solution may be a combination of green and grey solution

Grey solution - seawalls

- **seawalls** are often made of concrete or other hard materials and are designed to absorb and deflect the energy
- can be formed as gates that can be closed during storm surge



Grey solution - revetments

- **revetments** are sloping structures made of rocks or concrete blocks that are placed along the shore to reduce the impact of wave action and prevent erosion.
- **seawall and revetments** give immediate protection, often used in urban areas where property values are high
- they can have negative ecological impacts by altering natural coastal processes and can lead to beach erosion further downstream



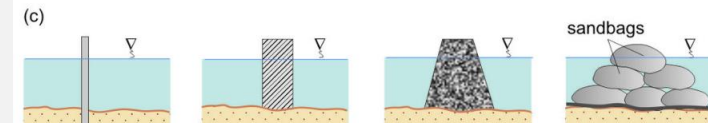
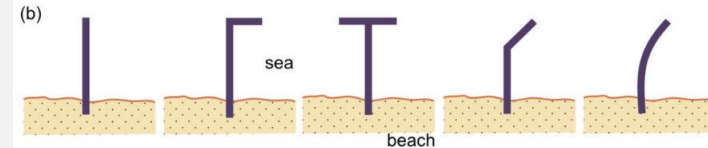
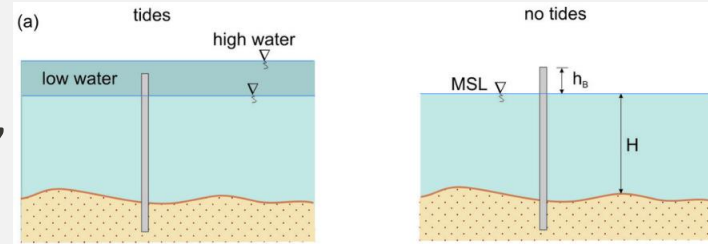
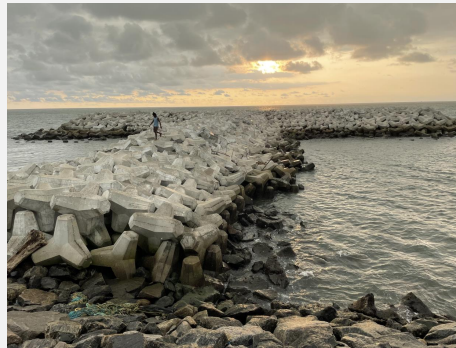
Grey solution - breakwaters

- ↗ **breakwaters** are offshore structures designed to break the force of incoming waves
 - can be submerged or partially visible and are used to protect harbors and coastal developments



Grey solution - groins

- **groins** (or groyne) are structures perpendicular to the shoreline
 - intended to trap sand and build up beaches.
- while breakwater and groins can effectively reduce erosion, they can also disrupt natural sediment transport, affecting neighboring coastal areas and ecosystems.



Grey solution – beach nourishment

- ***beach nourishment*** involves the artificial refilling of eroded beaches with sand or sediments
 - restores beaches
 - provides temporary protection from erosion
- widely used grey solution, but it requires periodic maintenance and can be expensive



Green solution – dune restoration and stabilization

- Planting native vegetation in dune systems helps stabilize the sand, making them effective natural barriers against erosion
- Dunes also provide habitat for coastal wildlife



NPS

Green solution – mangrove restoration

- mangrove forests are highly effective
 - reducing coastal erosion due to their dense root systems and wave-absorbing capacity
- provide essential habitats for fish and other marine life, contributing to ecosystem health



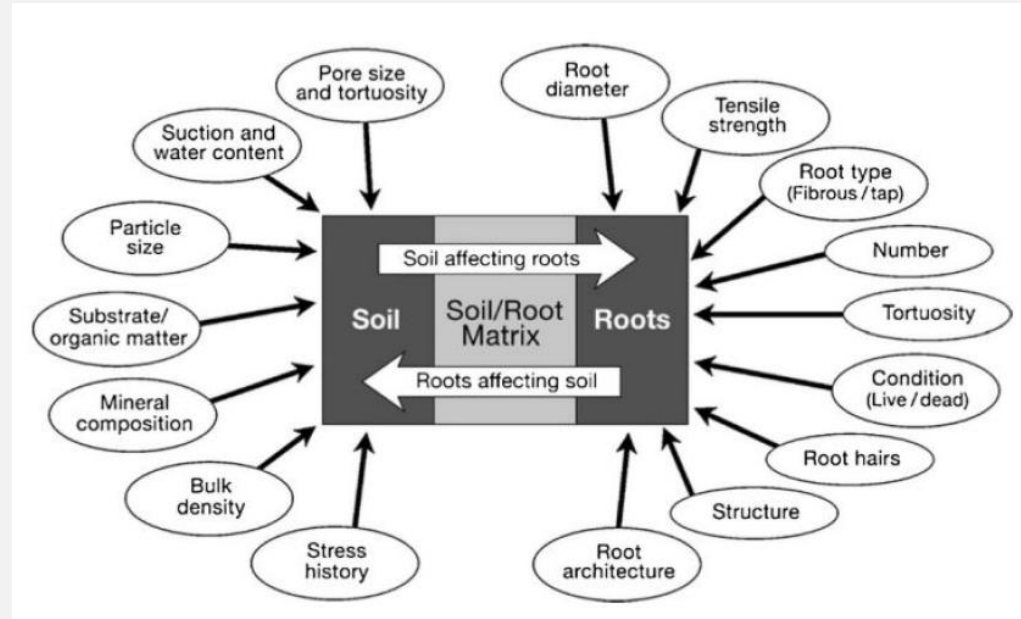
Vegetation as green solution (NBS)

- ↗ vegetation can reduce the flow by a factor of 2 to 10 (Koch et al., 2006)
- ↗ total wave dissipation will be increased by a longer vegetation field
- ↗ total wave dissipation will be higher with a higher stem density
- ↗ sediment shear strength increase is leading to less erosion

Vegetation in sea

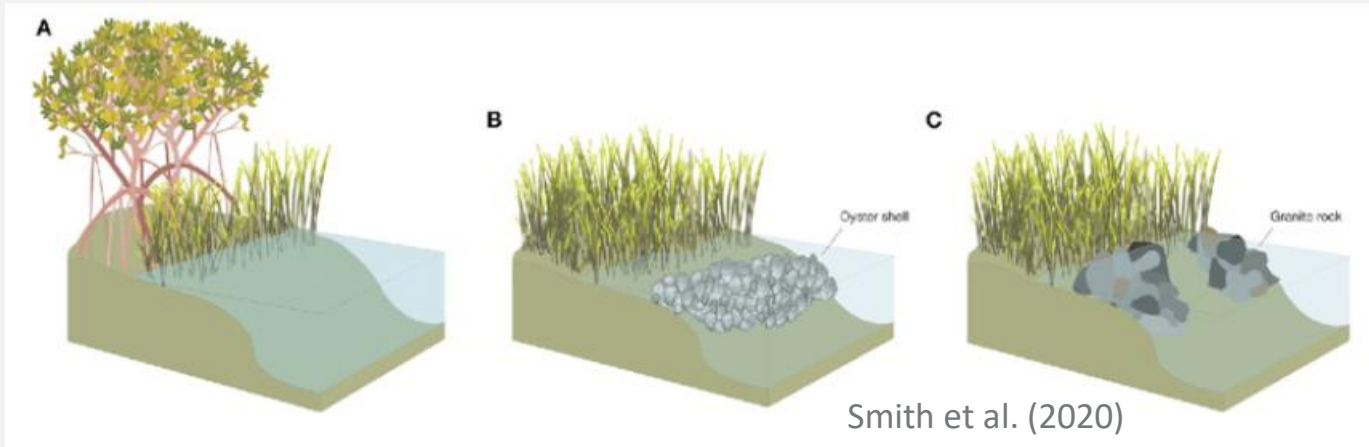
➤ The strength properties and root distribution in the sediment is important (Cazzuffi et al., 2014).

- Characteristics of the root system
- Mechanical characteristics of the root system
- Geotechnical and biochemical characteristic of the soil in contact.
- Environmental characteristics



Green solution – living shorelines

- ↗ use of natural materials like oyster shells, rocks, and native vegetation to protect and stabilize shorelines while providing habitat for marine life
- ↗ they are adaptable and can evolve with changing environmental conditions.



Green solution – salt marsh restoration

- ↗ ecologically valuable and provide natural protection against erosion
- ↗ they absorb wave energy, reduce flooding, and improve water quality



Green solution – reef restoration

- ↗ Coral reefs and oyster reefs can break wave energy and protect coastlines
- ↗ Restoration efforts include transplanting coral fragments and enhancing oyster populations



Example on dune restoration the Bellocchio Beach, Italy

OAL-ITALY



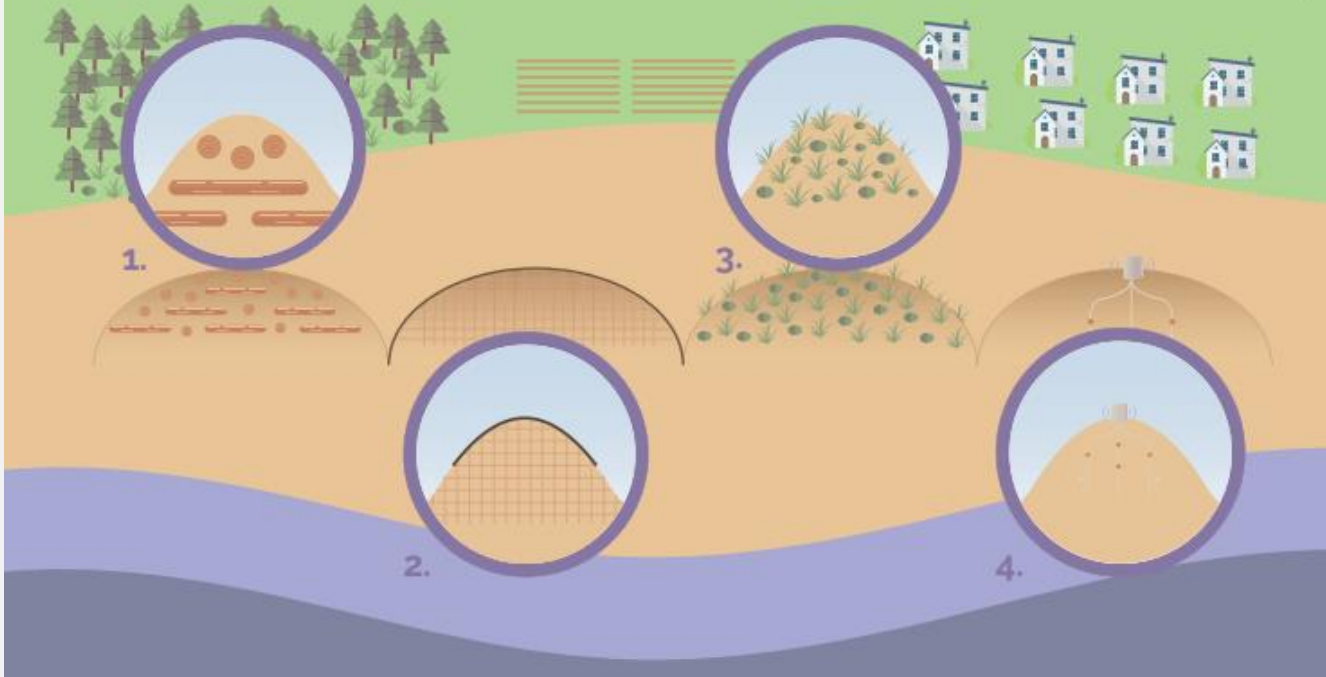
➤ Operandum – open-air laboratories (OAL)

<https://www.operandum-project.eu/>

Artificial dunes

An NBS to adapt areas to storm surges and coastal erosion.

Operandum has built a 50-metre long **sand structure** covered with **vegetation** to protect natural and agricultural lands and inland infrastructures from **extreme sea levels**.



1. Artificial dunes are frontline **beach protections** made up of **biodegradable** materials -wood logs and coconut geotextile- and **sand**. They mimic natural dunes in acting as barriers between the sea and the land.

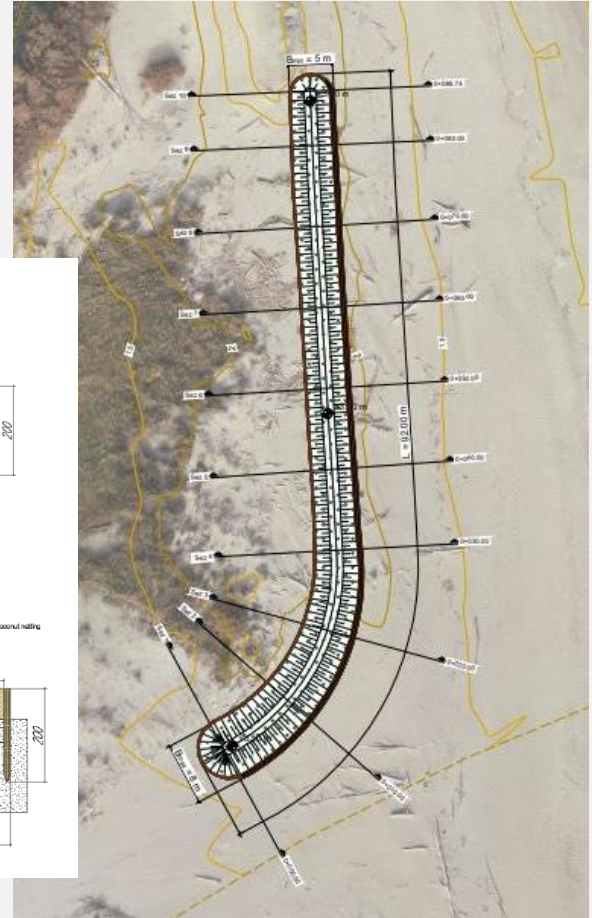
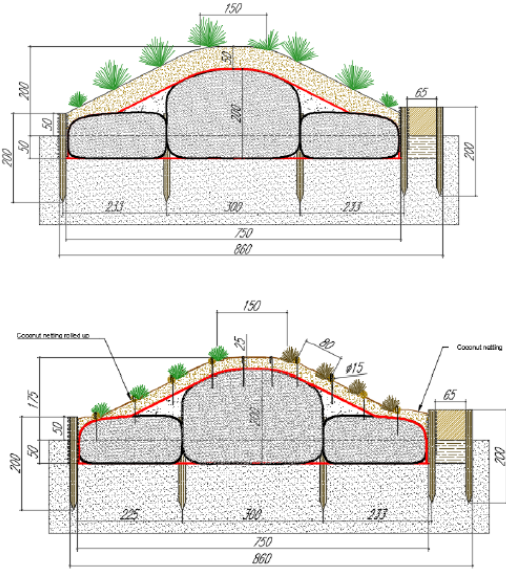
2. An **additional coconut geotextile** is placed atop the sandy dunes to control both **runoff** water and **erosion** and to hold **moisture** for the vegetation to grow.

3. The structure's front, top and back are covered with **native vegetation** that traps sand, **stabilising** and **reinforcing** the dunes.

4. Monitoring the dune's inner structure with fibre-optic sensors helps evaluate the NBS' **resistance** against storm surges as well as its **protective efficiency**.

OAL-Italy

➤ Bellocchio Beach – NBS design



(Operandum – OAL-IT)

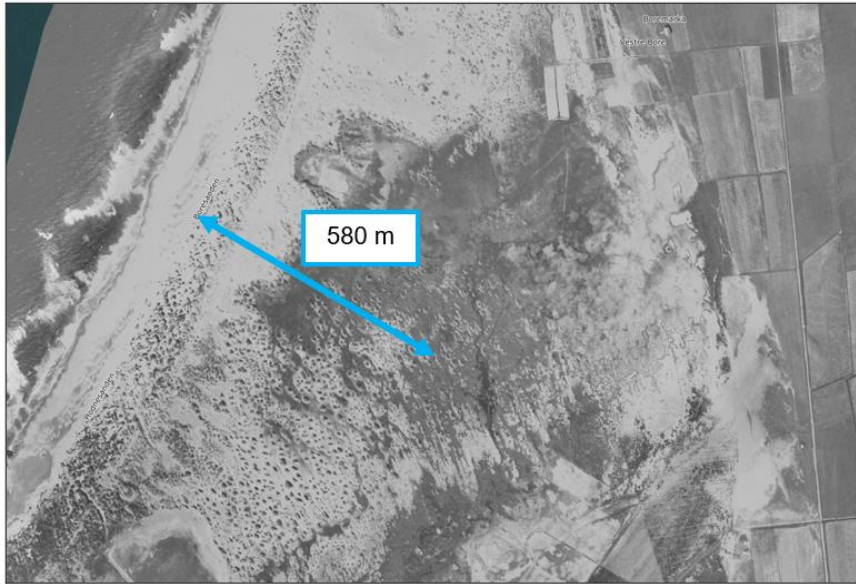
Example on dune restoration
the Bore beach, Jæren,
south-western Norway

Western Norway – Bore beach

- ↗ aeolian erosion
- ↗ planting of marram grass improved stability
- ↗ heavy erosion (from sea) during storms
- ↗ through a season the eroded material is refilled by onshore sediment transport



Bore beach (cont.)



Bore beach at 1937 (left) and 2019.

Kelp outside Bore beach

- near shore seabed along the Jæren coast is greatly covered with kelp
- presence of kelp has shown to reduce wave breaking which is an important factor for beach erosion
- kelp has the ability to "capture" eroded sand from sand dunes during a storm
- sand can thereafter be re-transported back to the dunes after the storm with on-shore sediment transport
- presence of kelp contributes in this way to a faster build-up of the sand dunes after heavy storms (Løvås and Tørum, 2001)



Kelp outside Bore beach

Sea dikes



Sea dikes



Storm surge barriers



Storm surge barriers

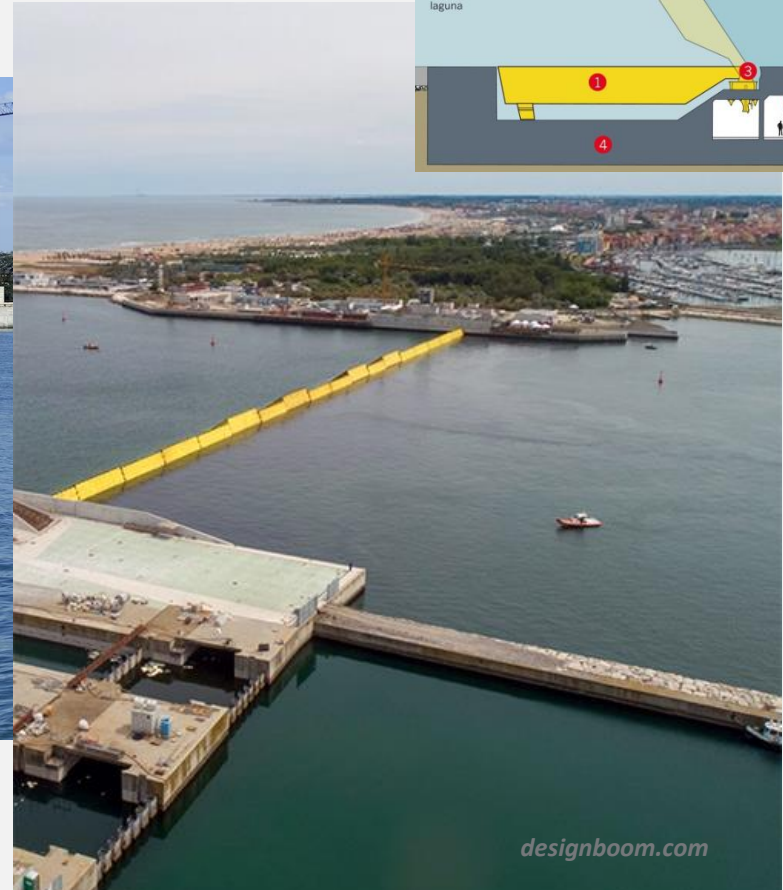
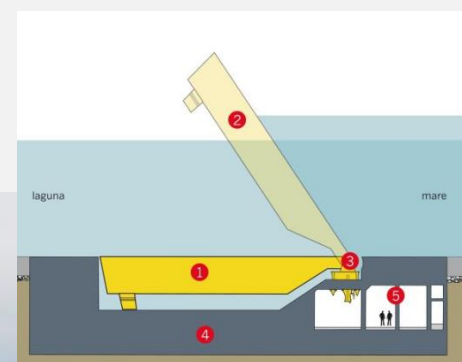


Storm surge barriers



Storm surge barriers - Venice

Lugi Constanti, AP



Revetments, geotextiles



Erosion protection, groins



Tetrapods and groins, Kerela, India



Erosion protection, groins; Barbados



Erosion protection, groins; Barbados - details



Land reclamation / groins



Dunes



Strategic planning and regulations

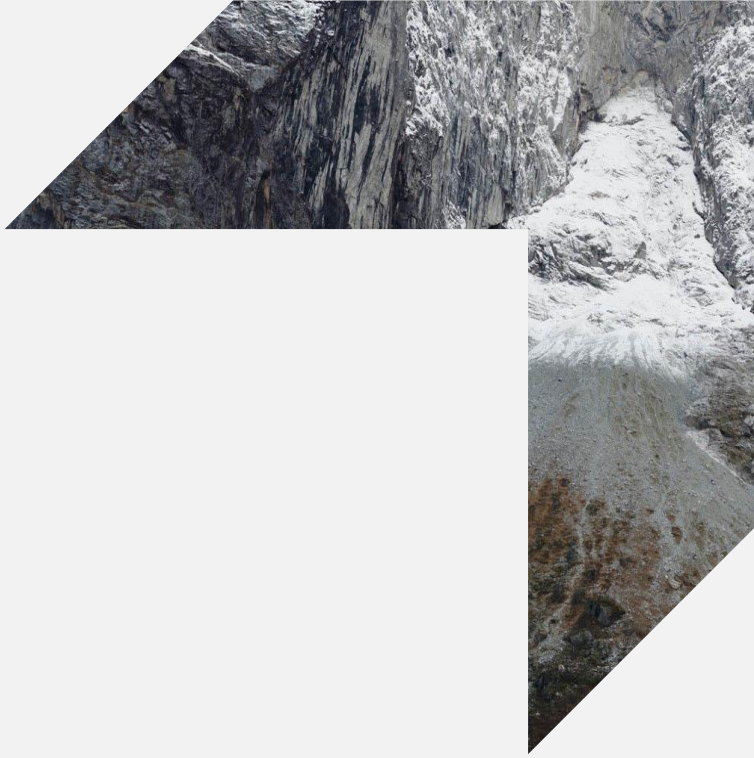
- ↗ Coastal erosion can also be managed through
 - regulations and land-use planning
 - limit development in vulnerable areas
 - establish setback lines
 - require elevated structures in flood-prone zones
- ↗ This approach helps reduce the exposure of people and property to erosion hazards

Monitoring and early warning systems

- Effective coastal defense also includes monitoring systems
 - track changes in shoreline erosion, sea level rise, and storm events
 - early warning systems can provide alerts and evacuation plans in the event of severe weather or erosion-related emergencies

Climate change adaption

- ↗ long-term adaptation strategies are essential
 - include managed retreat, building resilience in coastal communities, and considering future coastal dynamics in planning and development
- ↗ Choice of coastal defense strategy should be based on a combination of factors
 - specific characteristics of the coastal area
 - environmental impact assessments
 - cost-effectiveness.
- ↗ Sustainable and adaptive approaches that consider the long-term effects of climate change are increasingly emphasized in coastal management practices





#onsafeground