Coastal risks - assessment methodology based on the vulnerability index

Application to case studies in Portugal

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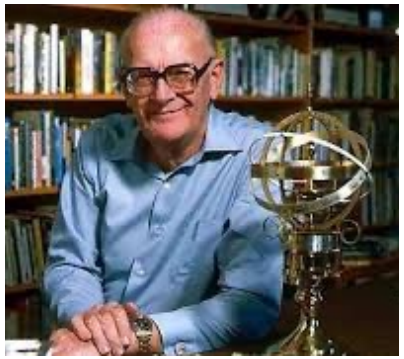
Summary

OCEANS

"How inappropriate to call this planet Earth when it is quite clearly Ocean!"

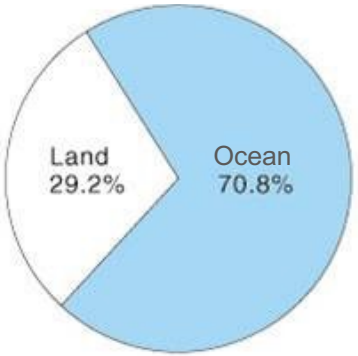
Arthur C. Clarke



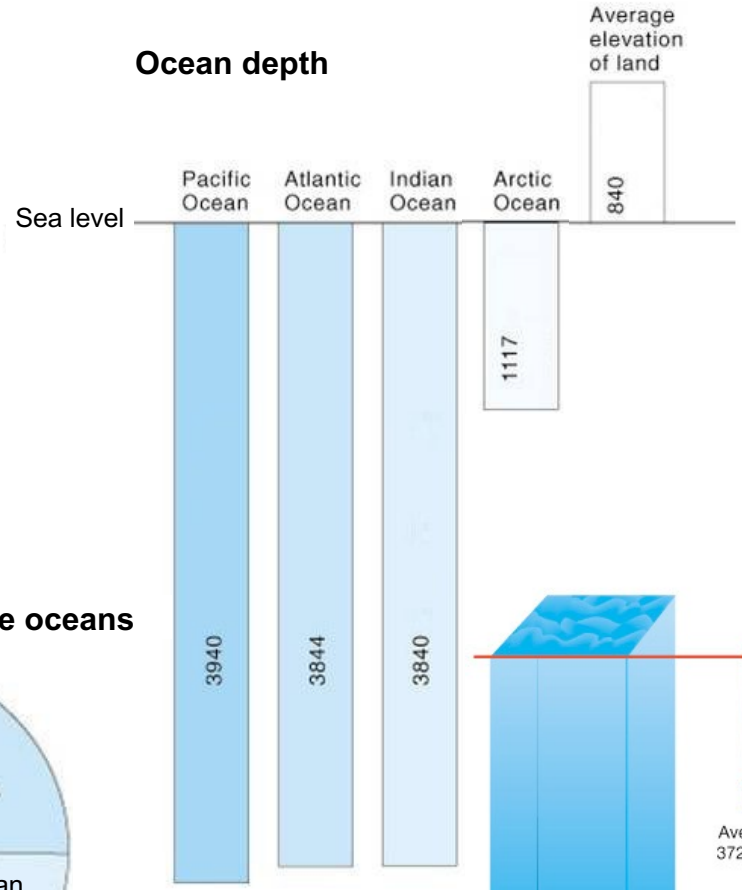
Arthur C. Clarke
(16/12/1917 – 19/03/2008)
British writer and inventor

OCEANS vs CONTINENTS

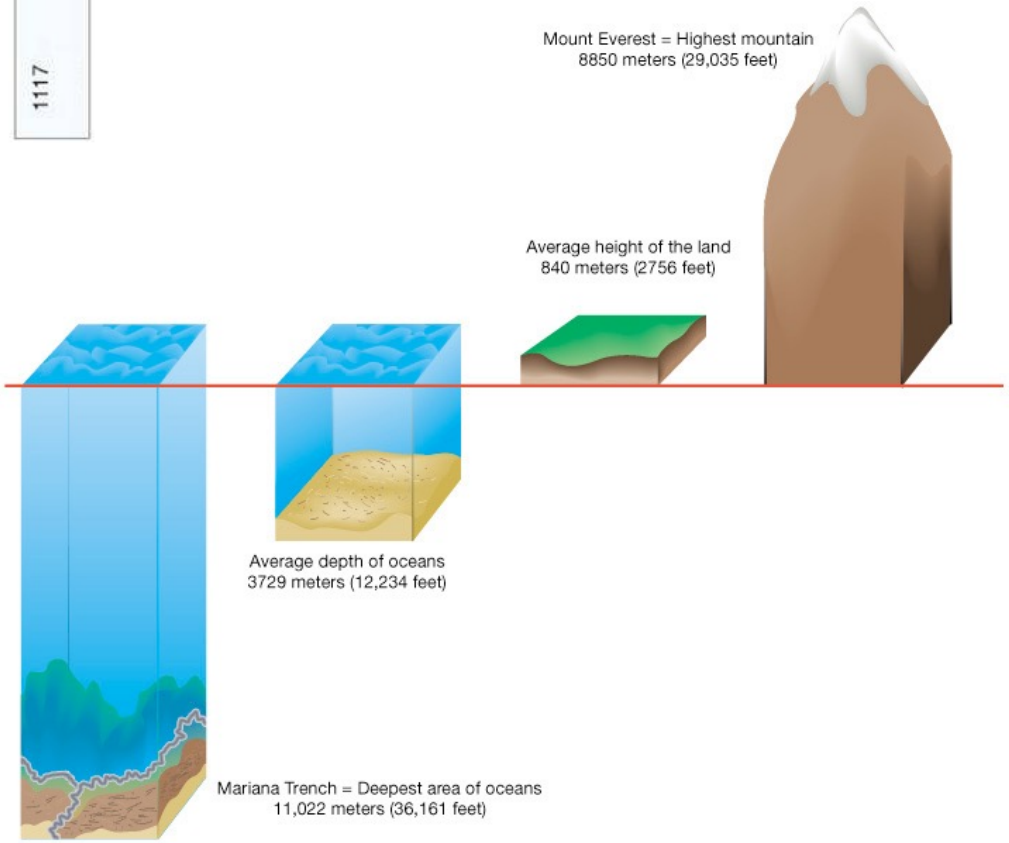
Earth surface



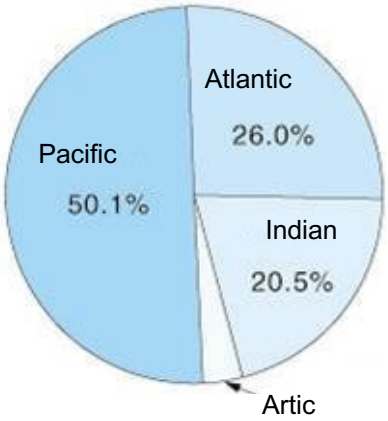
Ocean depth



Depth of oceans and altitude of continents



relative dimensions of the oceans



OCEANS IMPORTANCE

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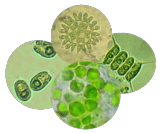
OCEANS IMPORTANCE



- Oceans support 3/4 of the planet's species of life
- ~70% of the oxygen released into the atmosphere is produced by phytoplankton during photosynthesis

plays an extremely important role in regulating the life of the planet

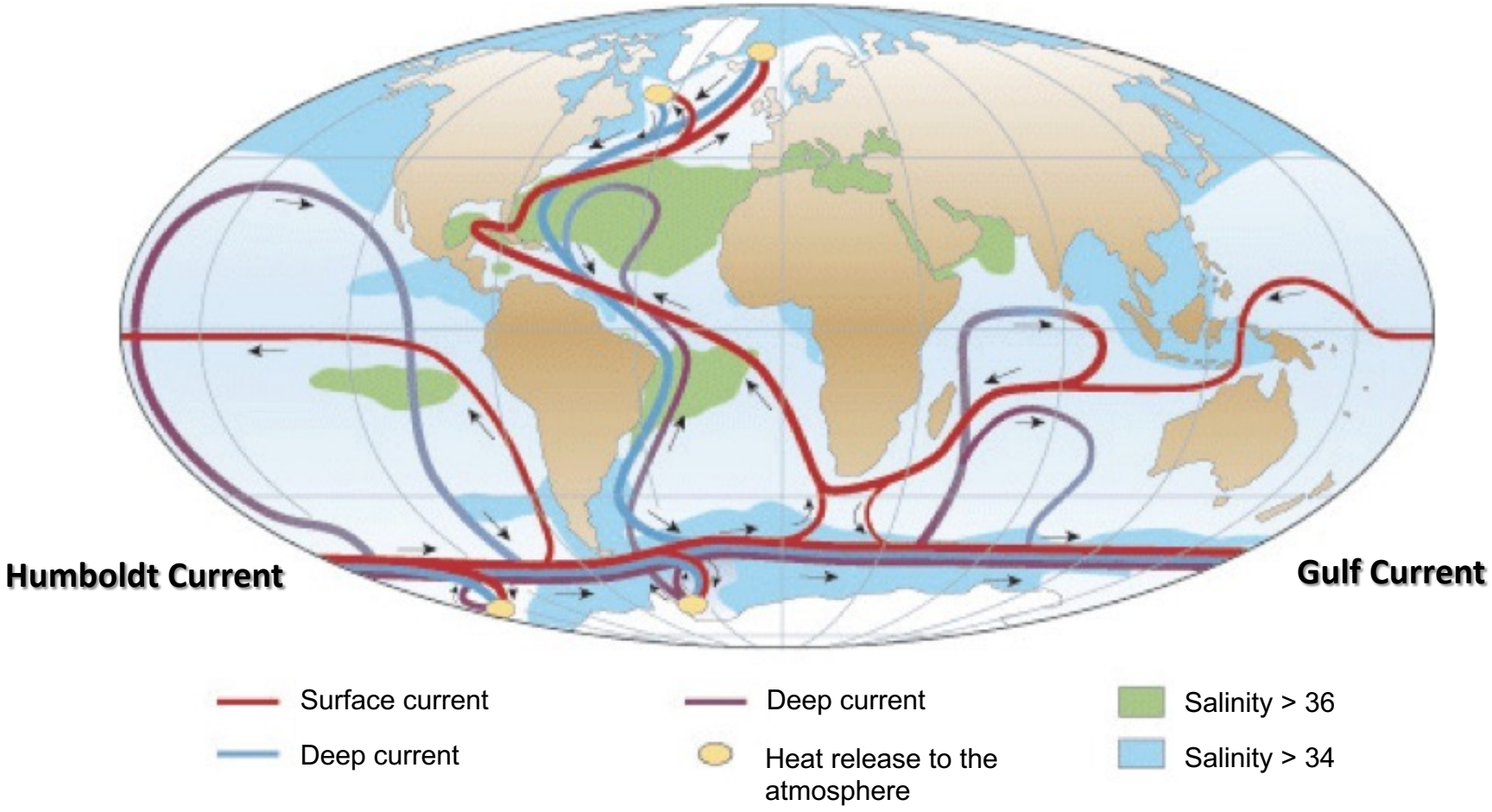
- The ocean contains 97% of all the water on the planet
- Interactions between ocean and atmosphere regulate the world's climate

Distribution of heat on the globe through marine currents

Importance in the water cycle

OCEANS IMPORTANCE

Currents work as a climatic factor, thermal regulator of the globe, influencing air temperature and humidity/precipitation



OCEANS IMPORTANCE

… Economic level

Mineral resources

- magnesium (used in metal alloys, especially with aluminum)
- bromine (used in the food, pharmaceutical and photographic industries)
- sodium chloride (table salt) (most important mineral)

Living resources

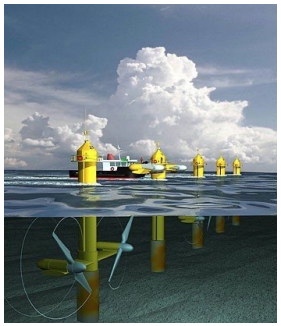
- 100 million tons/year of fish (main source of protein for 2000 million people)
- algae (used in the paper, photographic, food, pharmaceutical and wine industries)
- carapace of crustaceans (chitin is removed which is used in the treatment of burns and reconstruction of blood vessels)
- fish (compounds with applications in painting, lubricants and the rubber industry are removed)
- sponges (substances used in the manufacture of drugs to combat diseases such as cancer and AIDS are removed)

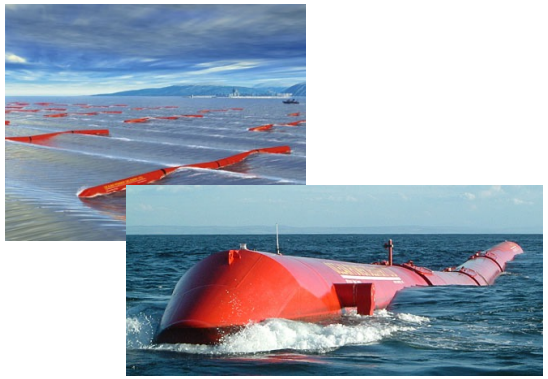
OCEANS IMPORTANCE

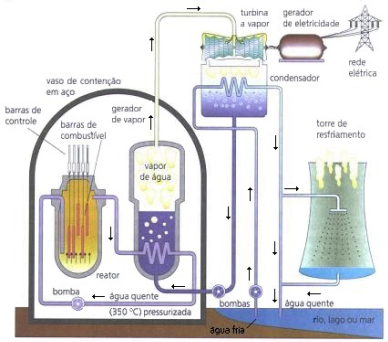
… Economic level

Energy source

- tidal power (converted into electrical energy)
- wave power (converted into electrical energy)
- cold water (cooling of thermal power plant turbines)







… Political level

Separate, divide and/or act as a border for continents and countries

COASTAL AREA

✓ one of the most complex, diverse and productive ecosystems on Earth

✓ located between the mainland and the ocean

✓ functions simultaneously as a protection and filter between aquatic and terrestrial systems, enabling numerous biological, chemical, physical, geological, oceanographic and meteorological interactions

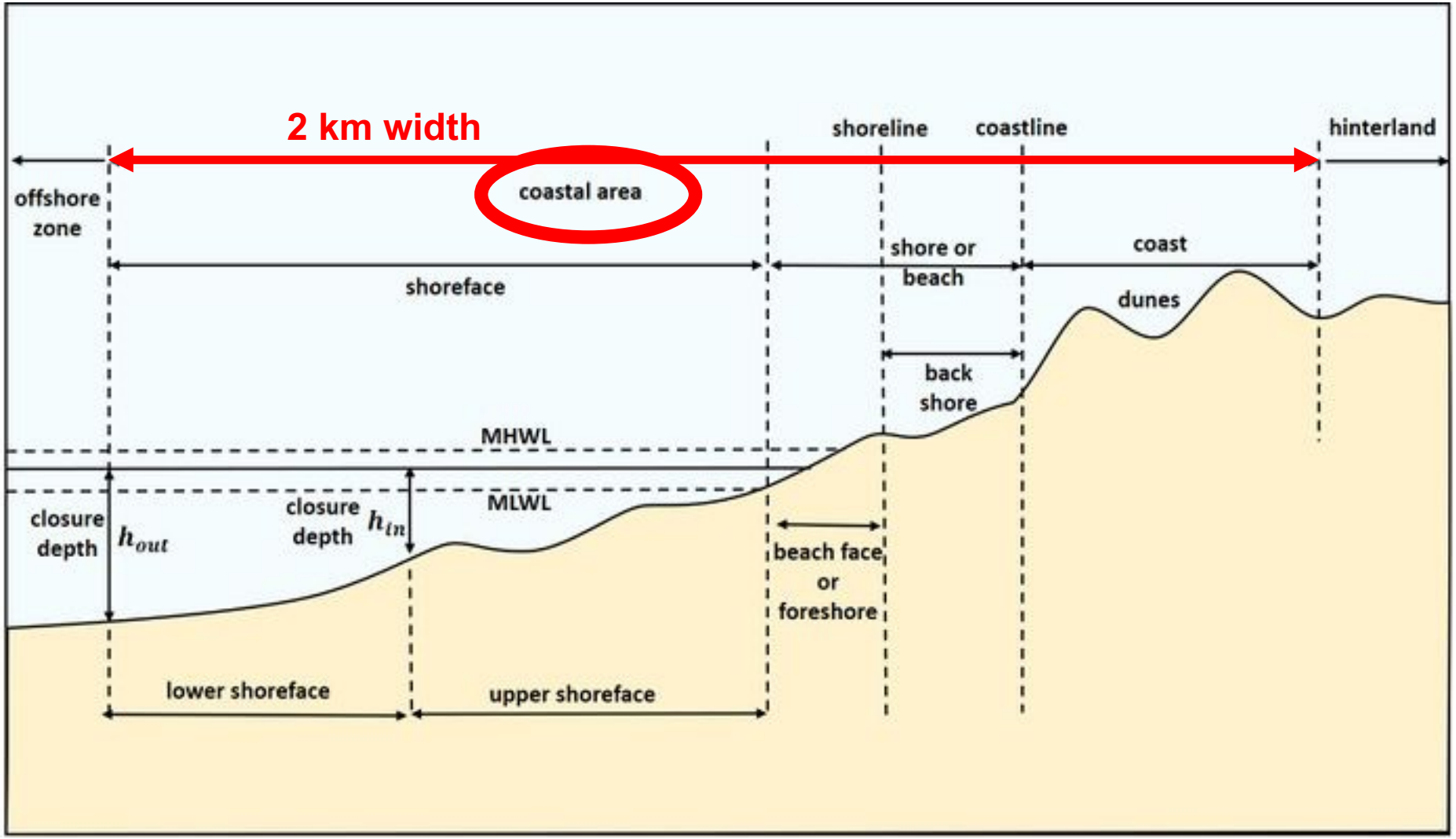
There is no consensus regarding the establishment of the physical limits of the coastal area, not only because these limits depend on the purpose and context in which they are established, but also because the physical and biophysical realities are very different in spatial terms

COASTAL AREA

According to the National Strategy for the Sea (Portugal):

"*Coastal zone is the portion of territory directly and indirectly influenced, in biophysical terms, by the sea (waves, tides, winds, biota or salinity) and which, without prejudice to adaptations to specific territories, has, on the landward side, the width of 2 km measured from the line of the maximum high tide of equinoctial waters and extends, towards the sea, to the limit of the territorial waters (12 nautical miles), including the seabed*"

COASTAL AREA



COASTAL AREA

- ❑ productive potential
- ❑ economically attractive and environmentally sensitive
- ❑ great socioeconomic value, since about 40% of the world's population lives within 100 km of the coastline
- ❑ is where most of the industries are located, due to the availability of water, the ease of transport (better roads, access to ports for the disposal of products and entry of raw materials) and the proximity of the largest economic centres
- ❑ **is of strategic importance at an environmental, economic, cultural and recreational level**
- ❑ **subject to great anthropogenic pressure**
- ❑ **subject to numerous risks**

EXERCISE

IDENTIFY THE RISKS

EXERCISE - *example*

For each image:

1) Identify the possible risks

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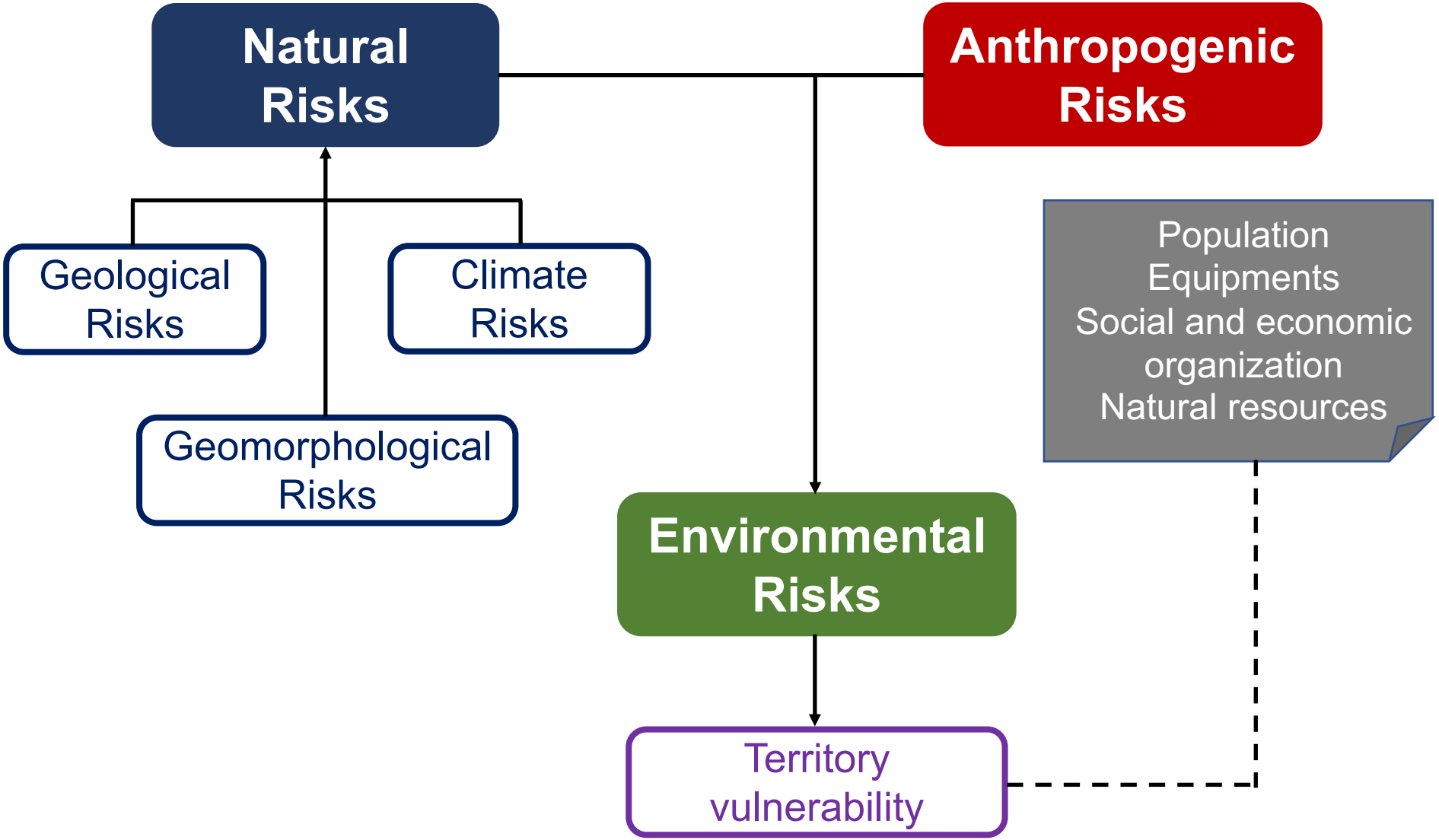
COASTAL AREA RISKS



COASTAL AREA RISKS

NATURAL RISKS		Causes	Consequences
Sandy shores	Coastal erosion	• Wind • Tides • Marine agitation (waves)	• Coastline retreat • Loss of territory and property • Reduction in the protection provided by the dunes • Damage to buildings and infrastructure
	Storm action	• Meteorology	• Induce punctual coastal erosion (non-permanent) • May induce permanent shoreline retreat in places with sedimentary faults • Destruction and loss of property
	Ocean overtopping	• Wind • Tides / *Storm surge* • Marine agitation (waves)	• Simultaneously induces erosion and accumulation • Important coastal changes in a short period • Can cause flooding of important areas • Can lead to the opening of tide bars
	Sea level rise	• Global warming • Specific actions • Anthropic actions	• Increase/acceleration of coastal erosion • Greater future possibility of coastal flooding • Increased wave's destructive capacity
Rocky shores	Mass movements	• Marine agitation (waves) • Precipitation • Wind • Temperature variations • Earthquakes / Vibrations	• Goods destruction • Habitat destruction • Loss of life
Coastal flooding		• Sea level rise • *Storm surge*	

COASTAL AREA RISKS

Anthropogenic Risks	Consequences	Protective measures
Greenhouse effect	• Increased frequency and intensity of thunderstorms • Sea level rise	• Reduction of GHG emissions • Climate change adaptation plans
Excessive occupation and disorder of the territory	• Accelerated erosion and sea water advance, with consequent threat to human life and destruction of property • Destruction of habitats and many migratory routes	• Construction of engineering works (spurs, walls, breakwaters, landfills) • Artificial feeding on sediments from certain beaches
Decrease in the amount of sediment reaching the coast	1) DAMS • Drastic decrease in the flow of sedimentary particles to the coast • Accumulation upstream and poor sedimentation downstream • Reservoirs end up being converted into aggregate deposition areas • Floods	• Territorial planning • Integrated coastal management
	2) EXTRACTION OF INERTS • Changes in currents • Reduction in the amount of sediment reaching the river mouth • Decreased fertility of some fish species in river estuaries • Irreversible changes in ecosystems	
Destruction of natural defenses		• Territorial planning • Integrated coastal management

COASTAL AREA RISKS

Personal accidents

COASTAL AREA RISKS

Personal accidents






COASTAL AREA RISKS

Personal accidents

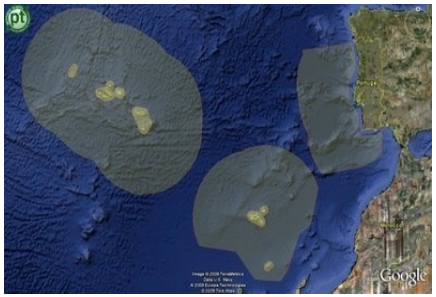
PORTUGUESE COASTAL AREA

- ✓ It has an extension of about 950 km
- ✓ Most of the big cities are there located

(Porto, Aveiro, Lisbon, Setúbal, Faro)

- ✓ 75% of the Portuguese population lives there
- ✓ Generated about 85% of the GDP

➢ Portugal has the largest Exclusive Economic Zone in Europe



➢ **The risks to which the coastal area is subject increase their vulnerability**

➢ The **occupation of risk zones increased the vulnerability** of populations to risks, which could cause serious disasters with irreparable losses

PORTUGUESE COASTAL AREA

Coastal Vulnerability Index

- Coastal vulnerability is a **spatial concept that identifies people and places that are susceptible to disturbances** resulting from coastal hazards

- The Coastal Vulnerability Index (CVI) is **one of the most commonly used and simple methods to assess coastal vulnerability to erosion, overtopping and/or coastal flooding**

- CVI can be an **useful information for coastal disaster management and building resilient coastal communities**

- CVI is a common tool **contributing to the decision-making process** in long-term coastal planning and management, enabling coastal managers to **prioritize or concentrate efforts on adaptation**

PORTUGUESE COASTAL AREA

Coastal Vulnerability Index

- CVI method is based on the physical and geological parameters and anthropogenic actions

- CVI was adapted to the Portuguese context

- The main areas of vulnerability will be identified by both CVI and the analysis of individual variables, also called coastal indicators, e.g.:
  - Geomorphology
  - Soil cover
  - Distance to shoreline
  - Tidal range
  - Wave height
  - Long-term shoreline erosion and accretion rates
  - Maritime agitation

PORTUGUESE COASTAL AREA

Coastal Vulnerability Index

	Vulnerability parameters	Vulnerability				
		Very Low 1	Low 2	Moderate 3	High 4	Very High 5
Representative natural and anthropogenic characteristics of the coastal area	Geology	Magmatic rocks	Metamorphic rocks	Sedimentary rocks	Sedimentary rocks	Small unconsolidated sediments
	Geomorphology	Mountains	Rocky cliffs	Erodible cliffs, sheltered beaches	Exposed beaches	Dunes, estuaries
	Soil cover	Florest	Low vegetation, cultivated soil	Uncoated soil	Rural urbanization	Industrial urbanization
	Anthropogenic actions	Maintenance interventions	Interventions without reduction in sedimentary sources	Interventions with reduction in sedimentary sources	No interventions and no reduction in sedimentary sources	Without interventions and with a reduction in sedimentary sources
Characterization of the coastal area	Topographic Dimension (m)	≥ 30	20 – 30	10 – 20	5 – 10	≤ 5
	Distance to shoreline (m)	≥ 1000	200 – 1000	50 – 200	20 – 50	≤ 20
	Maximum tidal range (m)	≤ 1.0	1.0 – 2.0	2.0 – 4.0	4.0 – 6.0	≥ 6.0
	Maximum wave height (m)	≤ 3.0	3.0 – 5.0	5.0 – 6.0	6.0 – 6.9	≥ 6.9
	Average rate of erosion/accretion (m/year)	≥ 0 Accretion	-1 – 0	-3 – -1	-5 – -3	≤ -5
	Maritime agitation	-	-	South coast	Southwest Coast (south of Cape Espichel)	Northwest Coast (north of Cape Espichel)

PORTUGUESE COASTAL AREA

Coastal Vulnerability Index

- CVI allows variables to be related in a quantifiable manner:

$$CVI = \sqrt{\frac{a_1 + a_2 + \cdots + a_n}{n}}$$

where a_i is the vulnerability (parameters)

- This method yields numerical data that cannot be directly equated with particular physical effects

However, highlight regions where the various effects of erosion, overtopping and/or coastal flooding may be the greatest

Low vulnerability (1.00 ≤ CVI < 1.41)

Moderate vulnerability (1.41 ≤ CVI < 1.82)

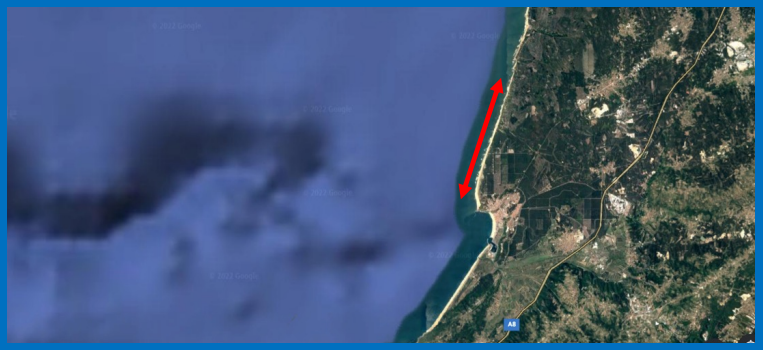
High vulnerability (1.82 ≤ CVI < 2.23)

EXERCISE

VULNERABILITY INDEX

EXERCISE - *example*

Praia do Norte, Nazaré, Portugal



Topographic Dimension (m)	15
Distance to shoreline (m)	174
Maximum tidal range (m)	4.1
Maximum wave height (m)	30
Average rate of erosion/accretion (m/year)	-2.2

Nazaré

https://www.youtube.com/watch?v=RuN2AnKyMio

Calculate CVI:

1) Google Maps (see the place)
2) Identify the geology, geomorphology and soil cover
3) Use the formula to calculate the CVI and classify the region

“God, to the sea the danger and the abyss gave.

But it was in him (ocean) that the sky was mirrored.”

Fernando Pessoa

Fernando Pessoa (13/06/1888 – 30/11/1935)
Portuguese writter

Setence from the poem “Portuguese Sea” of the book *Message* (1934)

QUESTIONS?

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