CSQ-4 Summary

Question	Knowledge Advancement Objectives	Observables	Measurement Requirements	Tools & Models	Policies / Benefits
How do interactions between climate change and local human activities impact coastal vulnerability and resilience?	A) Quantify the vulnerability and resilience of coastal environments to climate change	New and improved EO measurements of all ocean parameters, including: - sea level (sea surface height) - 2D total surface current vectors - 2D surface winds vectors - directional wave spectra including integral wave parameters (wave height, period, direction) - sea surface temperature - hyperspectral ocean colour - salinity - coastal bathymetry	Fine spatial resolution: - sea level, currents, winds, waves, salinity: 1km or finer - SST, ocean colour, bathymetry: 10-50 metres Fast revisit (daily, sub-daily, hourly) 2D mapping to observe space-time variability in complex coastal setup, with swath sensors or constellations. Measurements up to the land/water edge with uncertainty levels similar or better than offshore	Coastal circulation models at 1km or finer grid spacing Numerical wave models Coupled atmosphere-wave-ocean prediction/assimilation systems	UN Decade of the Ocean Actions (Increase community resilience to ocean hazards; Unlock ocean-based solutions to climate change) UN Sustainable Development Goal 14: Conserve and sustainably use the oceans, seas and marine resources GCOS, GOOS, and WCRP (ECVs)
	B) Quantify the vulnerability and resilience of coastal environments to local human activities	All EO observables of human activities, e.g land use, transport, agriculture, mining, water extraction, energy production, etc.		Digital Twins use 1km or finer grid spacing to evaluate benefits and impacts	
	C) Understand interactions between climate change and local human activities and their combined impacts on	Long term EO datasets Combine multiple EO datasets across domains, and with socio-economic data			

	coastal vulnerability and resilience				

CSQ-4 Narrative

The coastal zone is subject to intense stress linked to climate change (e.g. sea level rise, storm surges, high winds, extreme waves, heat waves, ocean acidification, deoxygenation, water cycle intensification, habitat and biodiversity losses) and anthropogenic pressures due to rapid coastal population growth, urban migration, land use change, freshwater extraction, subsidence, nutrient loading, pollution, overfishing, etc… (Singh et al., 2019). He and Silliman (2019) suggest that the interactions between climate change and local human actions can determine the vulnerability and resilience of coastal ecosystems. Better understanding of the interactions between climate-driven and human pressures on the coastal environment could help to identify where those pressures combine, to determine what mitigation strategies are most appropriate in which regions. Earth Observation can provide evidence about both climate change and socio-economic impacts and has an important role to play in assessing the vulnerability and resilience of the global coastal zone. Synergistic exploitation of EO datasets across the multiple Earth System domains (ocean, land, cryosphere, atmosphere) and the development of new and improved observations are needed to observe these complex coastal environments. EO can contribute to delivering comprehensive assessments of global coastal vulnerability and resilience to support the objectives of the UN Sustainable Development Goals and the UN Ocean Decade.

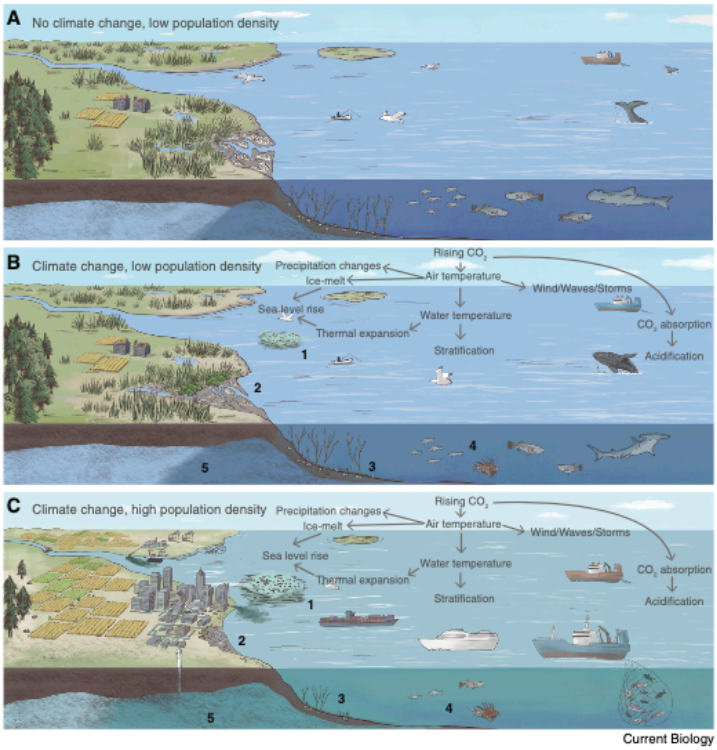

Figure 1. Impacts of climate change and local human activities on coastal ecosystems.
Shown is a temperate estuary adjoining land and ocean. (A) Scenario when the system is not affected by climate change. (B) Scenario when the system is pressured primarily by climate change. (C) Scenario when the system is pressured by both climate change and intense local human impacts. In (B), 1, climate warming promotes algal blooms [129]; 2, seaward loss and landward movement of coastal wetland as a result of sea level rise [102], and mangrove replacement of salt marsh grasses as a result of climate warming [105]; 3, warming-driven replacement of temperate seagrasses by subtropical seagrasses [130], and loss of bivalves due to ocean acidification [131]; 4, invasion of tropical fishes into temperate coastal waters and changes in fish species abundance and composition with warming [132]; 5, saltwater intrusion due to sea level rise [28]. In (C), 1, impacts of warming on algal blooms and hypoxia are exacerbated by eutrophication [12]; 2, loss of coastal wetlands due to the compounding effects of sea level rise and sea reclamations for urban, industrial and agricultural expansion [133]; 3, seagrass/bivalve loss is exacerbated due to synergistic/additive interactions between warming/ocean acidification and eutrophication [33,75]; 4, collapse of fisheries due to synergistic interactions between overfishing and warming [134]; 5, intense groundwater withdrawal exacerbates saltwater intrusion driven by sea level rise [28].

From He & Silliman, 2019

Observations and Geophysical parameters required: By definition, the coastal zone represents the interface between ocean, land, atmosphere and (in polar regions) the cryosphere. Understanding pressures and impacts at the coast call for multi-disciplinary cross-domain partnerships that bridge the traditional barriers between the land, ocean, atmosphere and cryosphere domains and communities. Efforts are needed also to develop new EO missions to sample the short temporal scales that dominate coastal regions (e.g. tides, diurnal warming), deliver high-resolution imaging of key parameters (e.g. directional wave spectra, wind vectors, total current vectors) and address data quality issues close to the land/water edge (e.g. sea level, salinity).

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