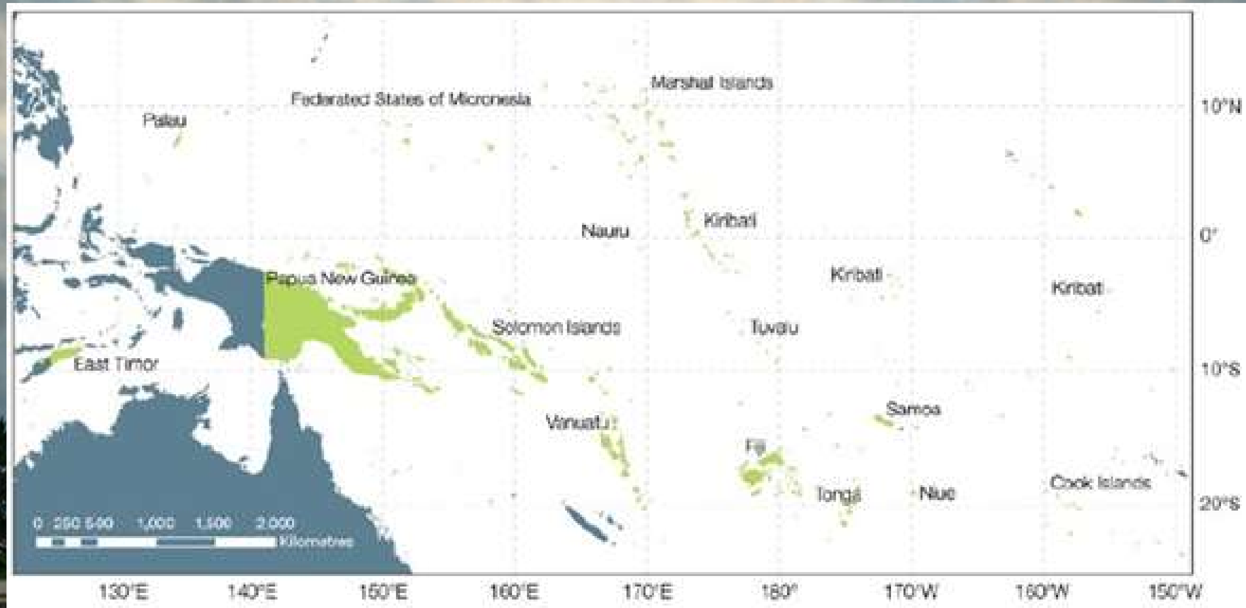

Australian Bureau of Meteorology & CSIRO (2011)

Sea Level Rise in the Pacific – Infrastructure Planning

Noelle OBrien, ADB Principal Climate Change Specialist

Natural Variability of Sea Level in the Pacific Islands Region

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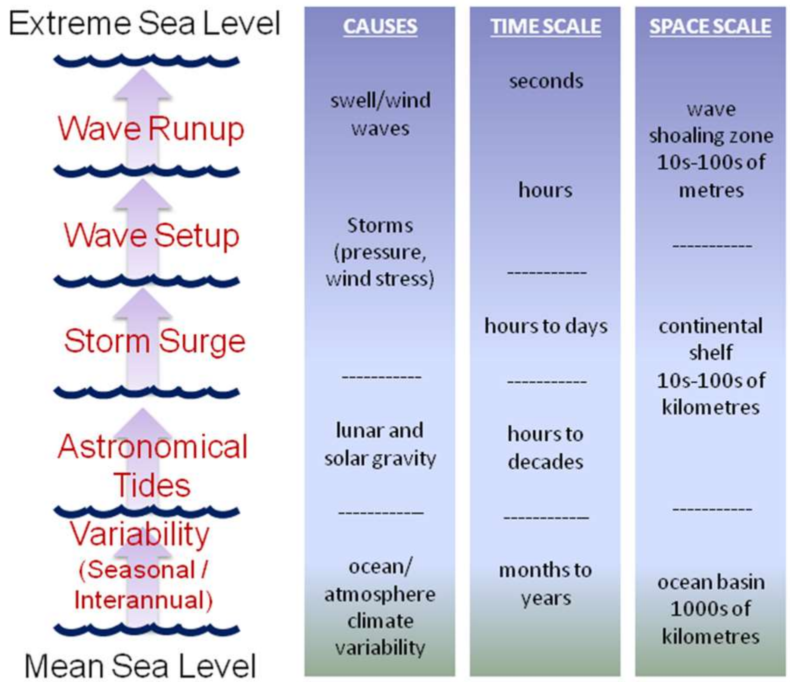
Sea level variability is naturally high

- Monthly, seasonal and interannual sea level anomalies are highly correlated with ocean-atmospheric modes such as the El Niño/Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation.
- Astronomical tides vary over multiple timescales (e.g., diurnal and semi-diurnal, fortnightly with spring and neap tides, and on seasonal to interannual timescales) and are often the largest contributor to both sea level variability and annual maximum sea level elevation.
- Astronomical tides also vary in space with the highest spring tides across the region ranging from 0.6 m in French Polynesia and the Cook Islands to ~2 m in eastern Micronesia.
- Storm surges -gravity waves arising from changes in pressure and wind stress - elevate sea levels by approximately 1 cm for every 1 hPa drop in atmospheric pressure relative to surrounding conditions. The magnitude of storm surge is also determined by storm track, storm intensity, bathymetry and the shape of the coastline.
- Wave Run-up and Wave Set- Up also influence Sea Level at any one location.

Ocean Phenomena that Contribute to Total Water Levels



CSIRO – McInness 2016

Sea Level Rise Associated with Climate Change

Since 1990, accelerating global SLR has been attributed to:
- increased rates of ocean warming/expansion
- ice melt due to warming of the planet by anthropogenic emissions of GHGs

The average rate of global mean SLR is increasing and the rate of increase is speeding up:

The IPCC Special Report on the Oceans and Cryosphere in a Changing Climate (SROCC) noted that average rates of global SLR have increased from:
- 2.06 mm/yr during 1970-2015, to 3.16 mm/yr during 1993-2015, and to 3.58 mm/yr during 2006-2015 (IPCC, 2019).

By 2100 global mean sea level is projected to rise by 0.28m to 0.55m (likely range) under a low greenhouse gas emission future, and 0.63m to 1.02m under a high greenhouse emission future.

Sea Level Rise will not stop at 2100.

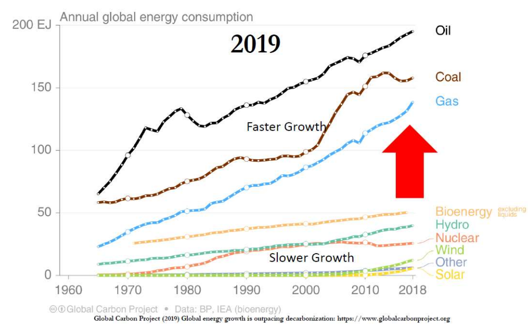
Beyond 2100 - large uncertainty in SLR projections – some suggest global mean sea level could reach 5m by 2150

This **uncertainty** presents a challenge for infrastructure planners and developers when considering new and existing critical infrastructure with long lifetimes. rise outcomes.

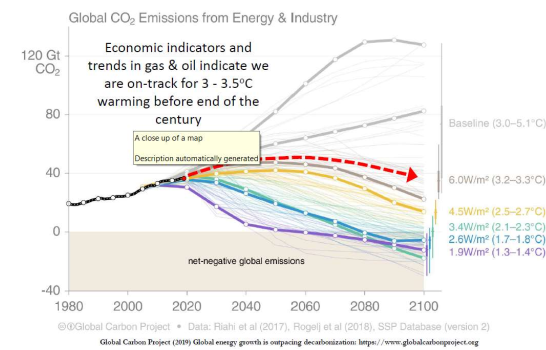
Why is there so much Uncertainty?

Fossil fuel use is accelerating faster than renewable fuel use

Renewable energy is not replacing fossil fuels, it is helping meet the demand for NEW energy

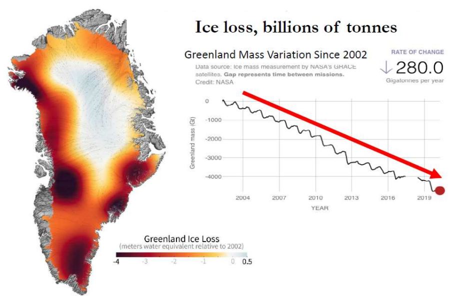


CO_2 Emissions Continue to Grow



Greenland melting has quadrupled since 2010

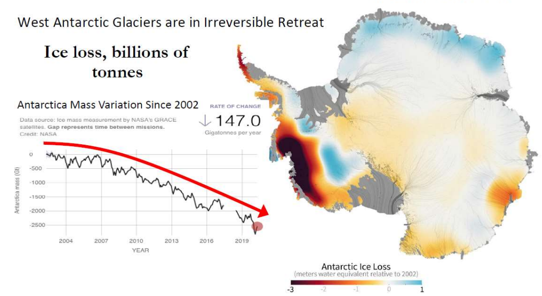
~26% of GMSLR



I. et al. (2019) Accelerating changes in ice mass within Greenland, and the ice sheets sensitivity to atmospheric forcing. PNAS, 116, 1934-1939.

Antarctic ice melt has tripled since 2010

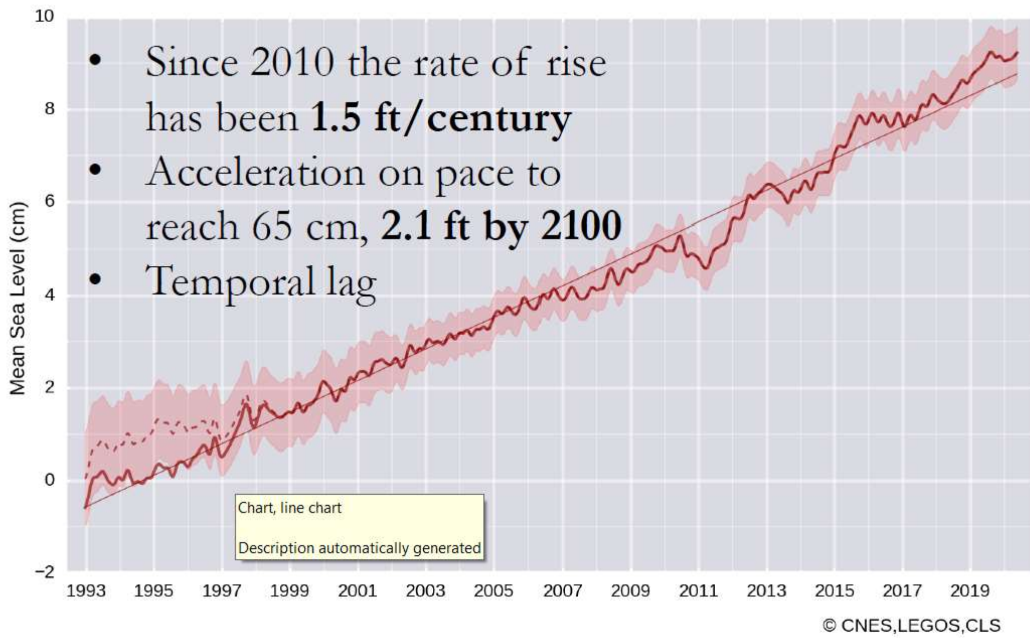
~14% of GMSLR



The IMBIE team (2018) Mass Balance of the Antarctic Ice Sheet, Nature, 558, pages219–222, https://doi.org/10.1038/s41586-018-0179-y

Certain of the Direction of Sea Level Rise

Global Mean Sea Level Rise 1993-2019
3.4 mm/yr or 1 ft/century



Nerem, R.S., et al. (2018) Climate-change–driven accelerated sea-level rise, *PNAS*, Feb, 115 (9) 2022-2025; DOI:10.1073/pnas.1717312115

ADB

Responses to Sea Level Rise

When developing infrastructure decision makers are required to consider the range of hazards

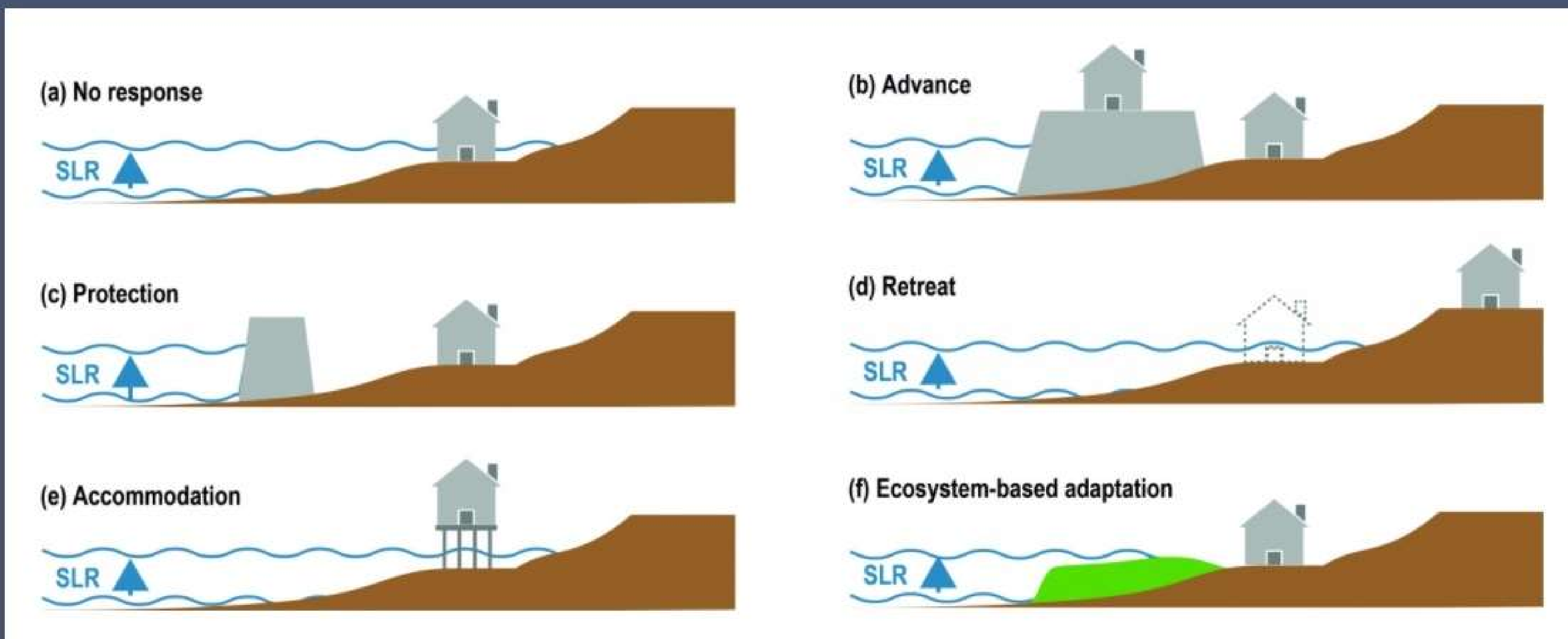
With uncertainty in the potential future Sea Level Rise it is necessary to consider a range of scenarios to consider the potential range of plausible future states.

When developing infrastructure decision makers are required to make a decision built around one of the three categories:

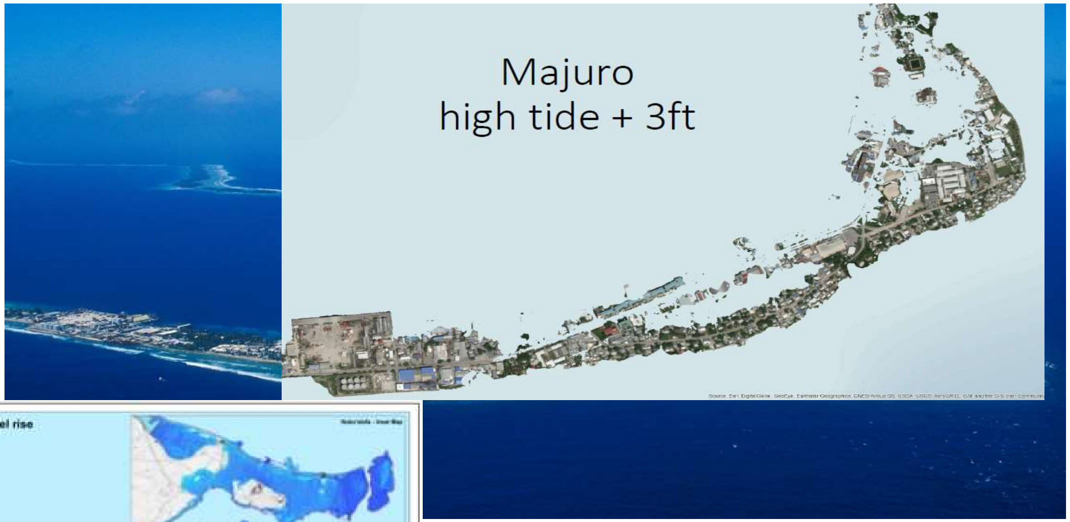
- **Accept the hazard:** where the hazard from sea level rise including coastal processes is low or the asset can easily be adapted to accommodate the effect of sea level rise.
- **Adapt to hazard:** accepting that the range of uncertainty of the hazard is wide and determine potential responses dependent on the level of sea level rise. Adapting to the hazard is predominantly related to existing infrastructure but may include making conscious decisions for new infrastructure to ensure modification in the future is possible to mitigate risk.
- **Avoid hazard:** proactively locating infrastructure outside of the potential hazard zone.

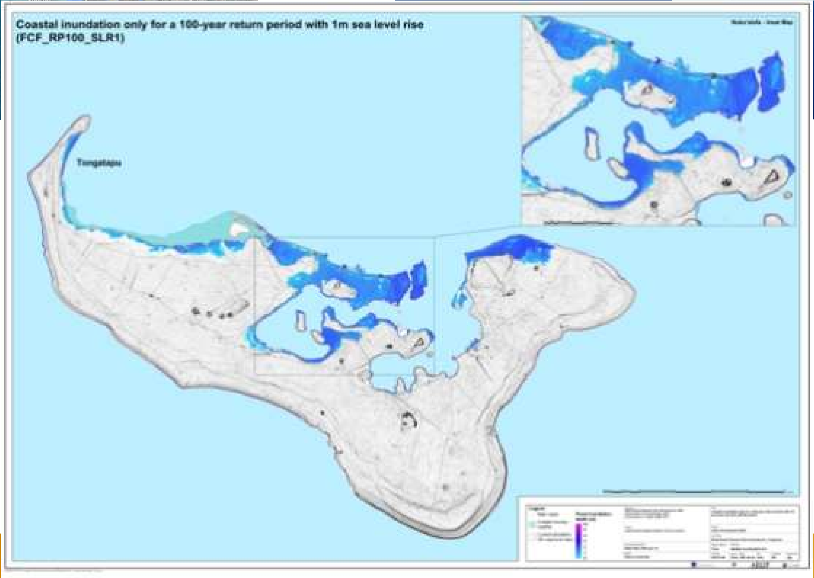
Responses to Sea Level Rise 2

Box 4.3, Figure 1 | Different types of responses to coastal risk and sea level rise (SLR).



Modelling Sea Level Rise Scenarios





Principles to Consider for Future Infrastructure

- Use the most up-to-date and robust science to determine regional sea level rise projections.
- Distinguish between global mean sea level and local (relative) mean sea level.
- Consider regional subsidence due to Seismic activity which may result in higher sea level rates
- Consider the range of potential climate scenarios and possible futures.
- Recognise that SLR will continue to rise for several centuries, & rate is dependent on future global decisions on CO2 emissions

- Use a risk-based approach to determine the level of risk that is acceptable for infrastructure design
- Hazard analysis and vulnerability and risk assessments should be completed to determine how different scenarios will affects design, level of service, maintenance, and viability.
- Evaluate a range of pathways to address uncertainty and develop a range of outcomes that can be implemented in an adaptative manner at defined trigger/decision points as the future unfolds.
- Flexibility is required to account for the degree of risk, likelihood of future consequences including criticality of the infrastructure and sensitivity to coastal hazards, permanence of the activity and adaptive capacity of the community and assets.
- For anticipated long life or greenfield developments and critical new infrastructure (which will have lock-in implications) a planning timeframe of 100 years should be considered in association with the 8.5H+ projection.
- Stress test future climate sensitivity and adaptative capacity of the activity, policy options or land use plan.

Examples of Projects – Significance of future SLR

Consequence of Failure	Description	Importance Level	Minimum Transitional Response
Low	Low consequence for loss of human life, or small or moderate economic, social or environmental consequence.	1	Minor structures (failure not likely to endanger human life. Adopt SSP2-4.5 projection considering design life.
Ordinary	Medium consequence for loss of human life, or considerable economic, social or environmental consequence.	2	Normal structures not falling into other levels. Adopt SSP3-7.0 projection considering design life.
High	High consequence for loss of human life, or very great economic, social or environmental consequence.	3	Major structures and critical infrastructure. Adopt SSP5-8.5 projection considering design life.
		4	Post disaster structures Adopt SSP5-8.5H+ projection considering design life within a minimum of 100 years.

Slide 11

NO1 Noelle O'brien, 10/10/2021

Thank you.