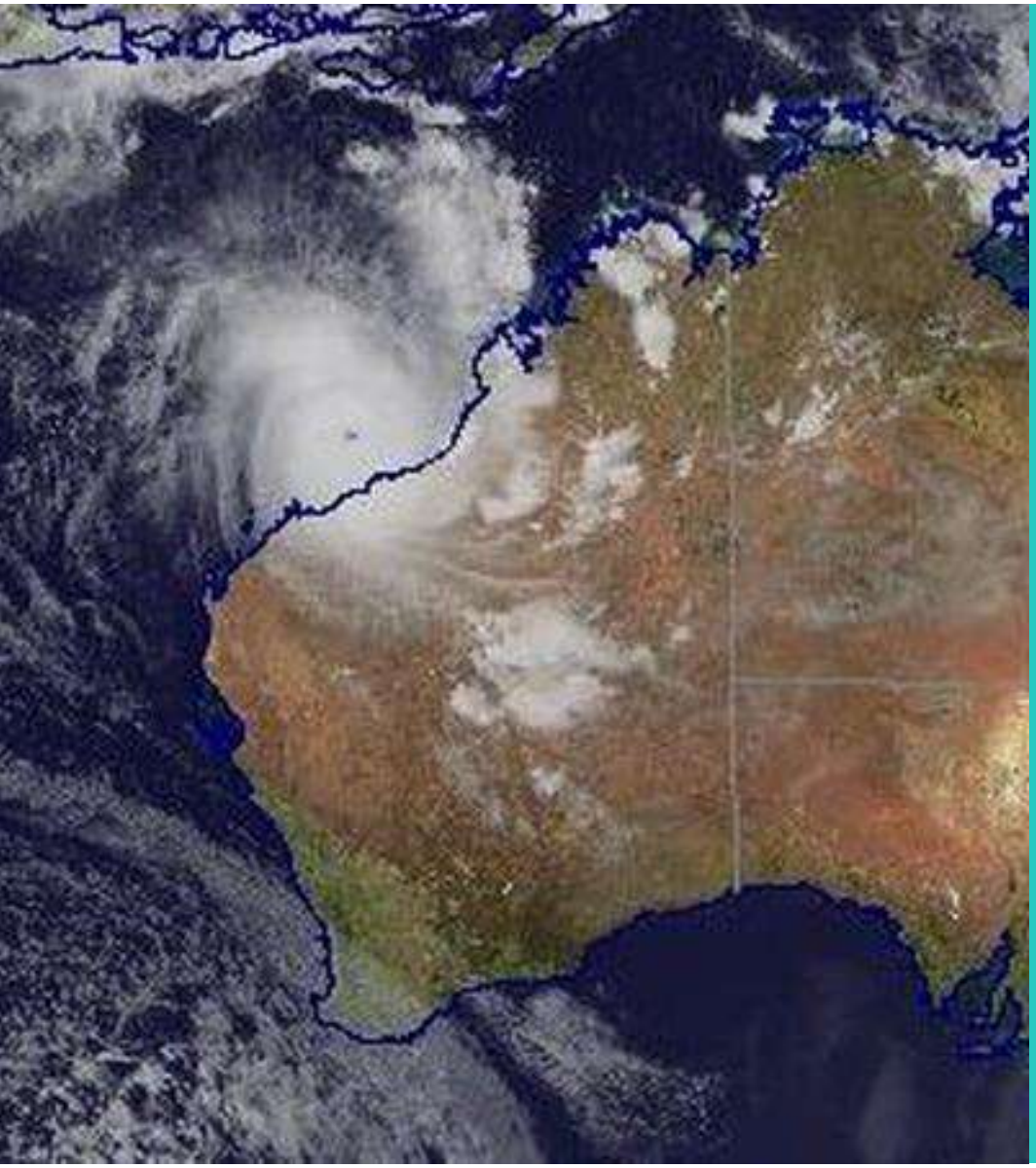


Tropical Cyclone Modelling to Determine Defensible Design Conditions

PIANC APAC 2024

Anuja Karunarathna

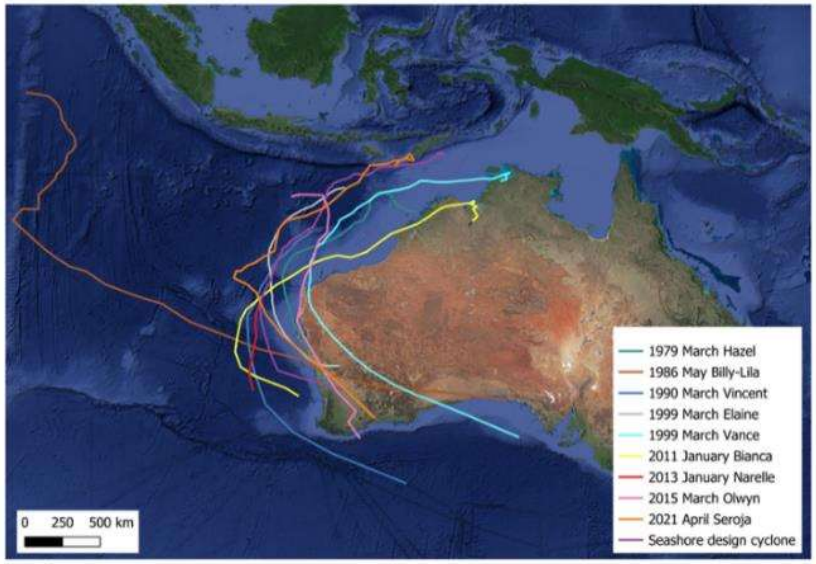
29 August 2024

Background

- Climate change impacts on TCs:
  - Move southwards
  - Become more severe
  - Increase the occurrence of severe TCs
- TC impact assessment methods
  - Monte Carlo method
  - Seashore Engineering (2018)
- Present study
  - Efficient and cost-effective method to obtain reliable design conditions
  - Simulation of selected historical and potential future cyclones in a fine resolution mesh

Methodology

- Modeling suite
  - MIKE 21 coupled Hydrodynamic Flow (HD FM) module and Spectral Wave (SW) module
- Simulation scenarios
  - **Historical cyclones:** nine selected cyclones (from BoM) and Seashore Engineering (2018) design cyclone
  - **Future cyclones:** Historical cyclones with 0.4 m SLR
  - **Modified future cyclones:** by increasing intensity and/or shifting the tracks of 'future cyclones'
- Extreme Value Analysis (EVA)

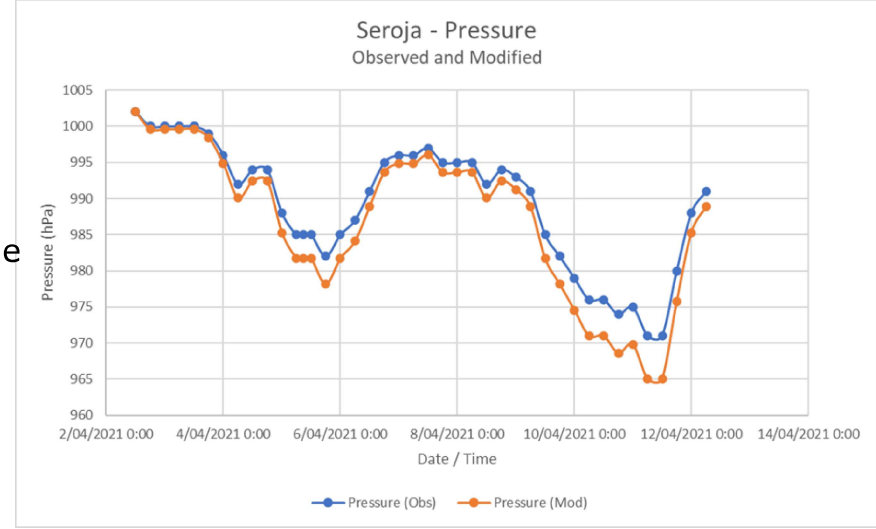


Tracks of selected historical cyclones and Seashore design cyclone

Modified future cyclones

- 'Modified future cyclones' were created by:
  - Decreasing the central pressure with increase of peak wind speeds (9 events)
  - Shifting the track of Billy-Lila 1.5 degrees of latitude to south (Billy-Lila modification 1)
  - Combination of decreasing the central pressure and shifting the track of Billy-Lila as above (Billy-Lila modification 2)
- Change in wind speed was estimated using:
  - $V_{max} = C(P_{ref} - P_c)^n$

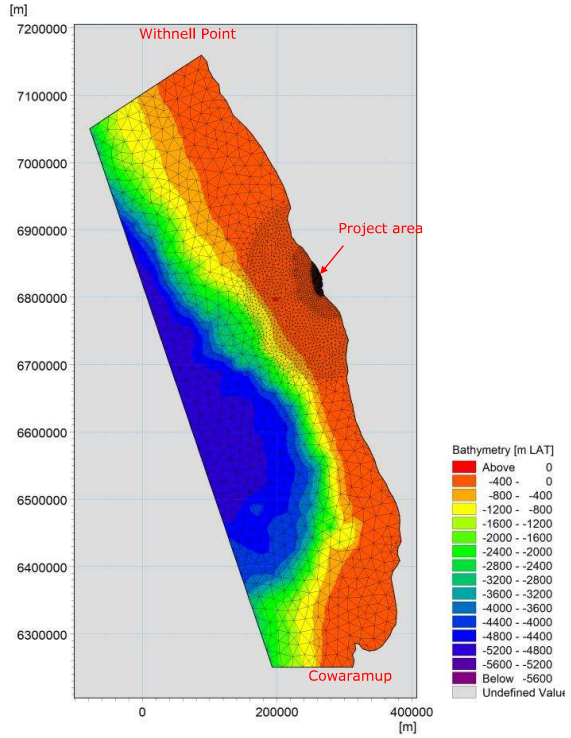
P_{ref} = a reference MSL pressure in hPa (typically p_n)
P_c = estimated MSL central pressure in hPa
C = an empirical constant C=2.16
n = an empirical exponent n=0.77

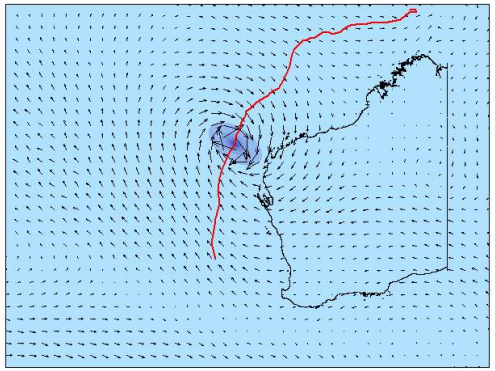


Example of pressure reduction

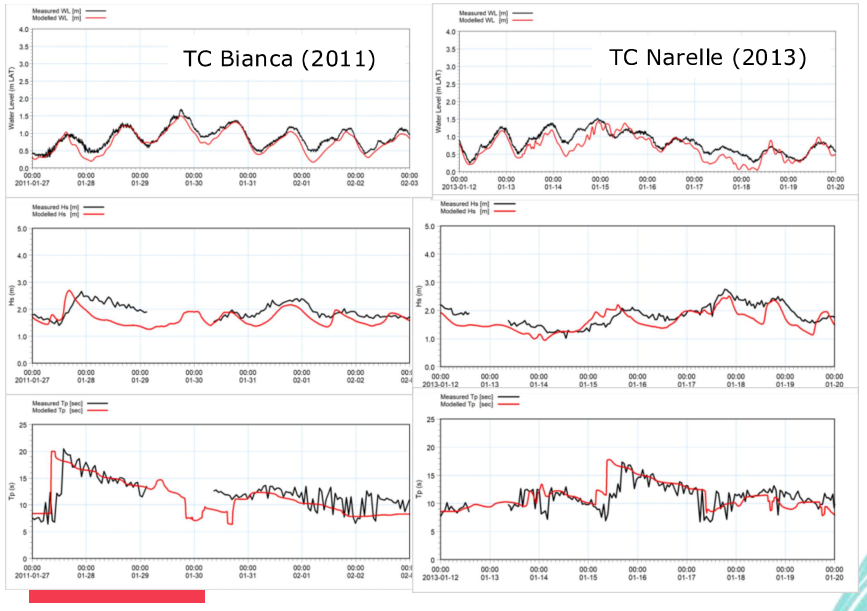
Model setup

- Boundary conditions
  - Offshore tides from the global tide model
  - Offshore waves from Worley's Indian Ocean Model
- Main driving forces
  - Tropical cyclone pressure and wind map generated using MIKE zero tool based on BoM data
  - Ambient wind conditions from NOAA NCEP Climate Forecast System Reanalysis (CFSR)





Model calibration and validation



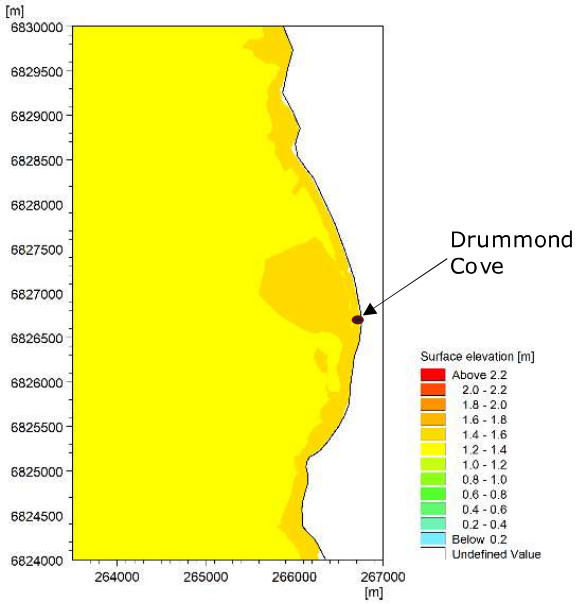
TC Bianca (2011) comparison statistics

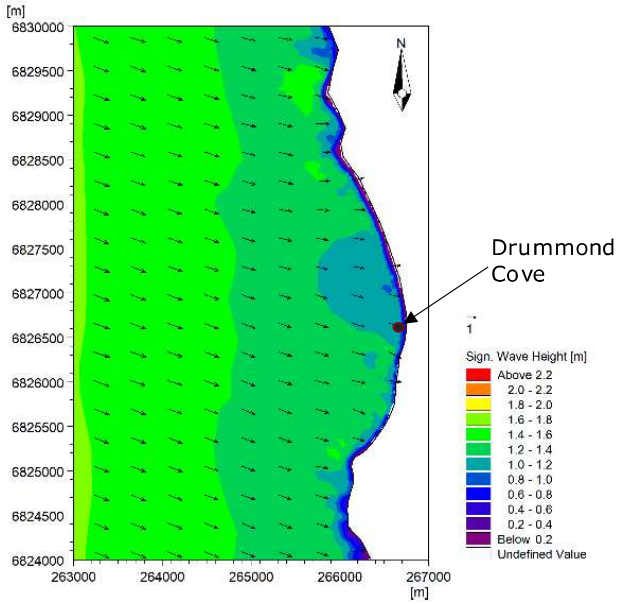
Parameter	IOA	RMSE	Bias
Water level	0.94	0.16 m	-0.12 m
Hs	0.57	0.38 m	-0.21 m
Tp	0.77	2.7 s	-0.52 s

TC Narelle (2013) comparison statistics

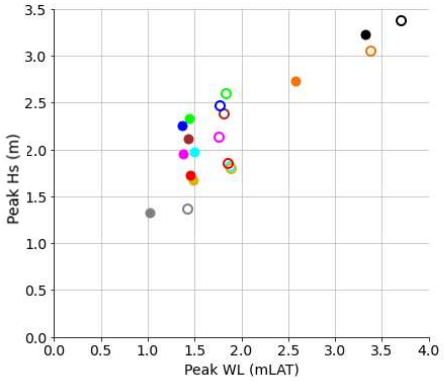
Parameter	IOA	RMSE	Bias
Water level	0.90	0.20 m	-0.14 m
Hs	0.75	0.39 m	-0.11 m
Tp	0.69	2.7 s	0.75 s

Model results

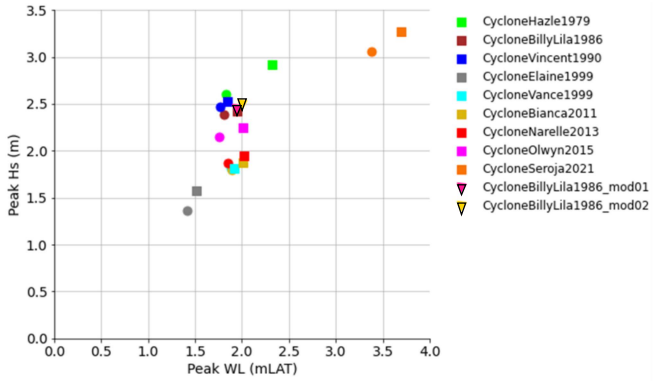




Peak WL and Hs



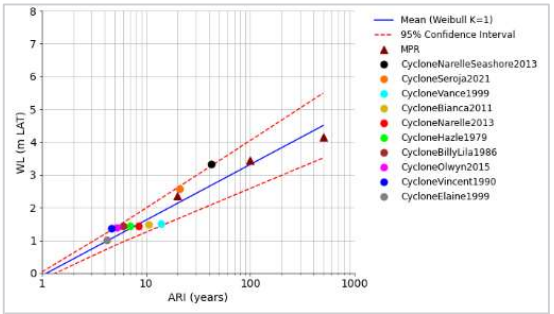
Historical cyclones vs 'Future cyclones'
(filled circles: historical cyclones
empty circles: 'future cyclones')

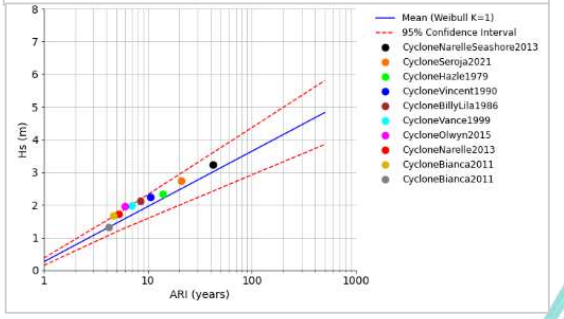


'Future cyclones' vs 'Modified future cyclones'
(filled circles: 'future cyclones'
squares: 'modified future cyclones')

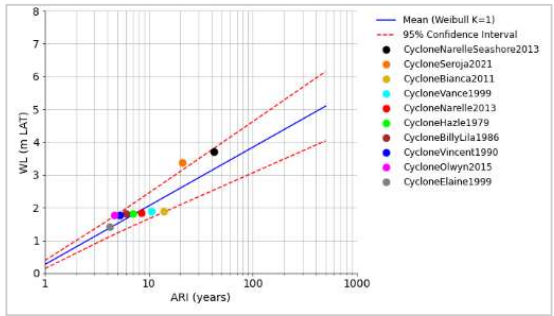
Parameter	Peak WL	Peak Hs
% increase from historical to 'future cyclones'	30%	7%
% increase from historical to 'modified future cyclones'	40%	14%

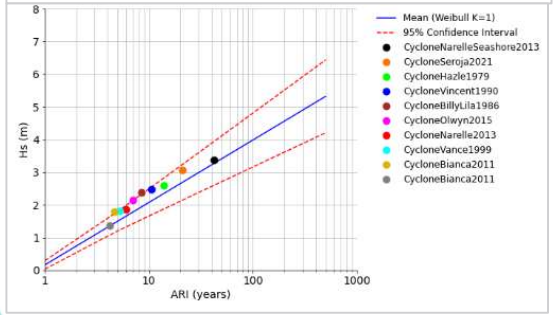
Extreme WL and Hs





Historical cyclones

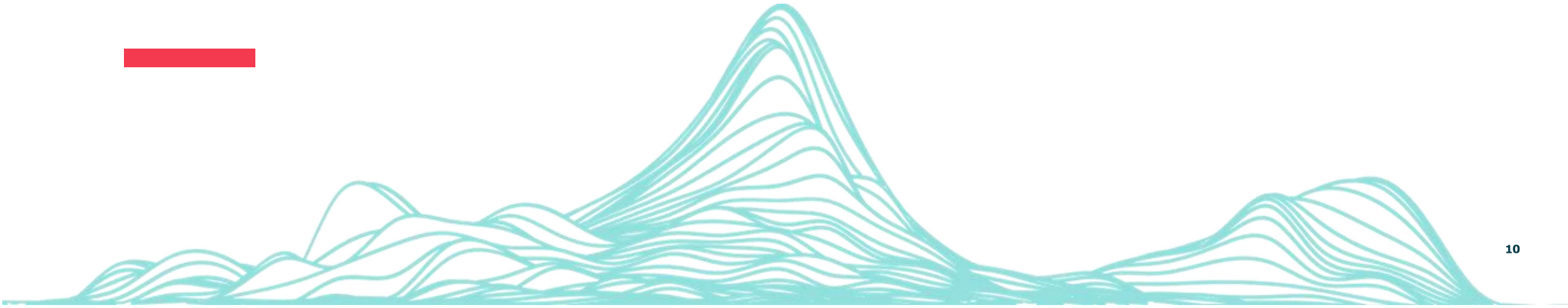




Future cyclones

Conclusions

- Water level and significant wave heights were increased due to changing climate.
  - increase in peak WL and peak Hs: 40% and 14%, respectively
  - increase in extreme WL and extreme Hs: 18% and 10%, respectively
- It is important to include climate change impacts on TCs when determining design conditions.
- The method adopted is an efficient and cost-effective method to obtain reliable design conditions due to TCs including the impacts of climate change.
- One limitation in the study is the extreme conditions may not be valid for low ARI's (eg., less than 10-year ARI) but it provided reliable extreme conditions for high ARI's.



Relevant UN SDGs

- Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable

11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels	11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030	C200304
	11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies	C200305

- Goal 13: Take urgent action to combat climate change and its impacts

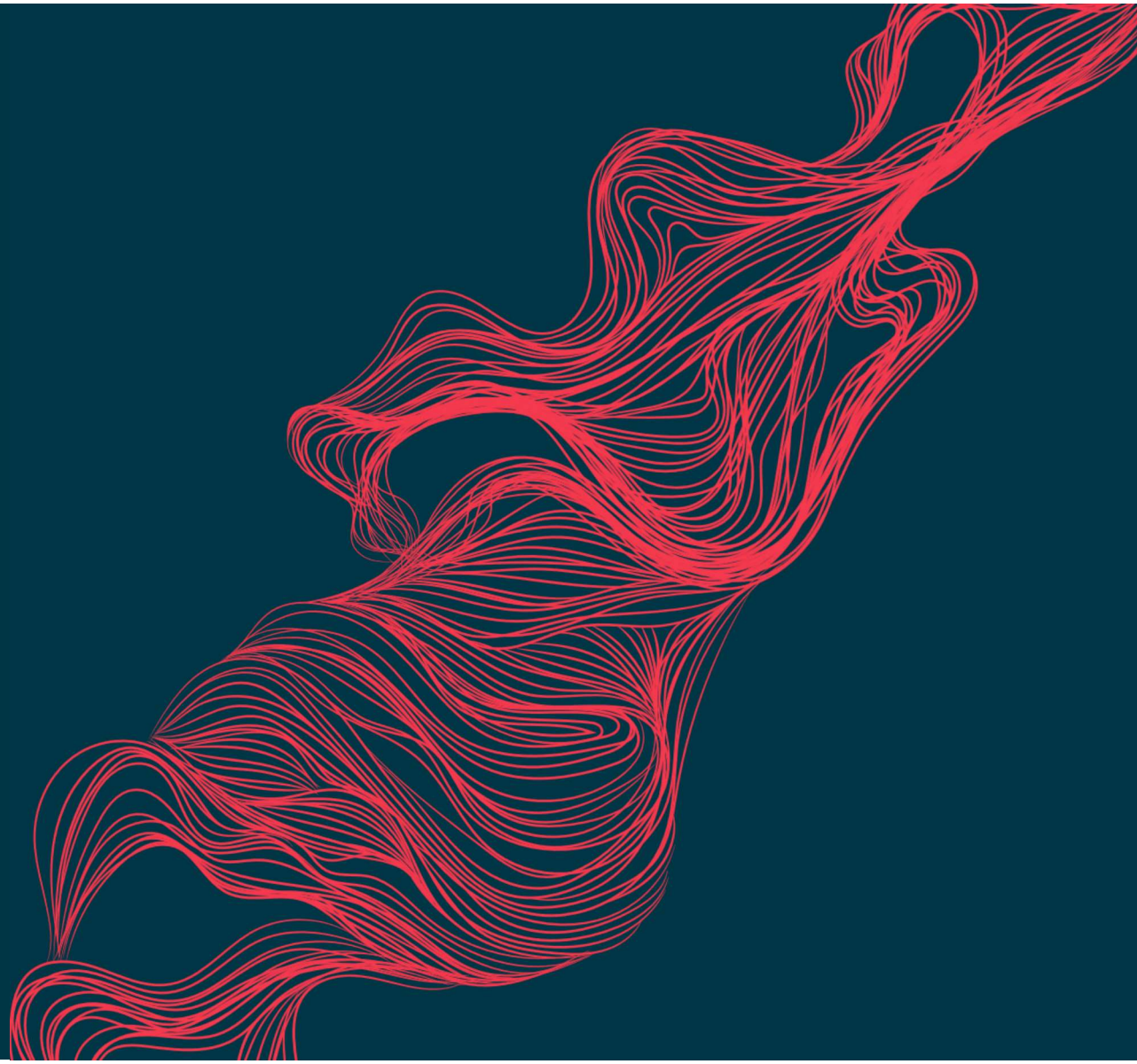
13.2 Integrate climate change measures into national policies, strategies and planning	13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications	C130203
	13.2.2 Total greenhouse gas emissions per year	C130202

Q&A

worley consulting

Contact Us:
N: Anuja Karunarathna
E:Anuja.K@worley.com

worley.com



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