Climate stress testing for waterborne infrastructure

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Introduction

Artwork by Maurice Goolagong 2023

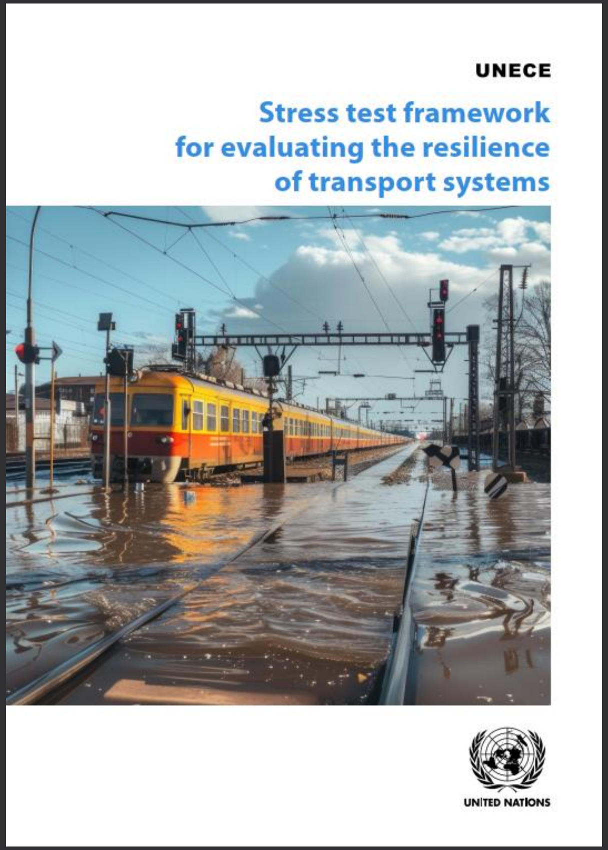
Definition

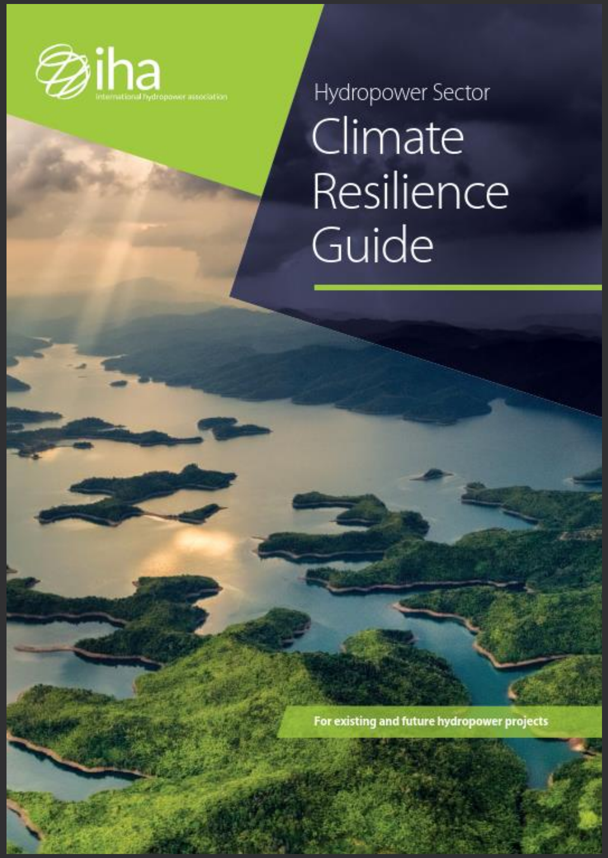
- Stress Testing in financial sector: “a technique to test the stability of an entity or system under adverse conditions”

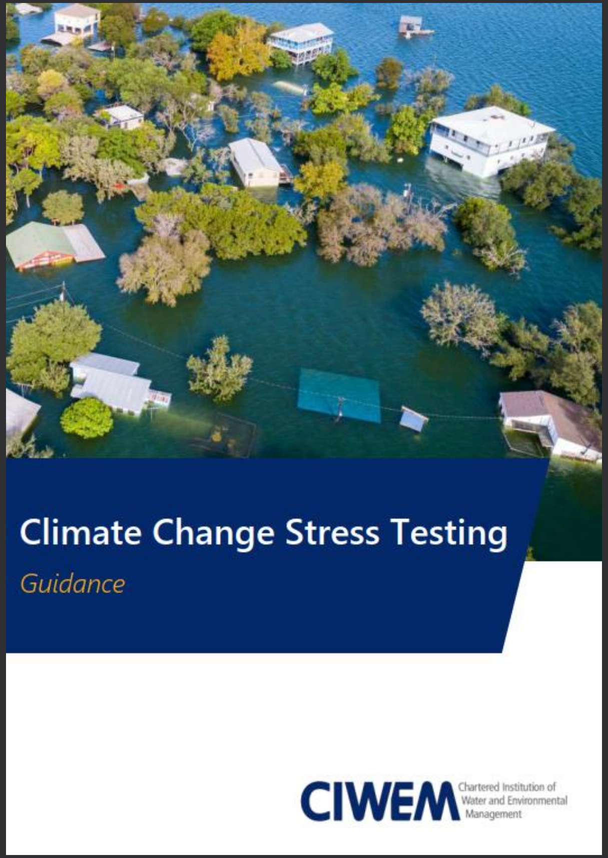
- “Stress testing is a process for assessing the ability of a system to maintain a certain level of functionality under unfavourable conditions, and understanding the consequences if this functionality is not maintained”

CIWEM, 2023

Existing guidelines







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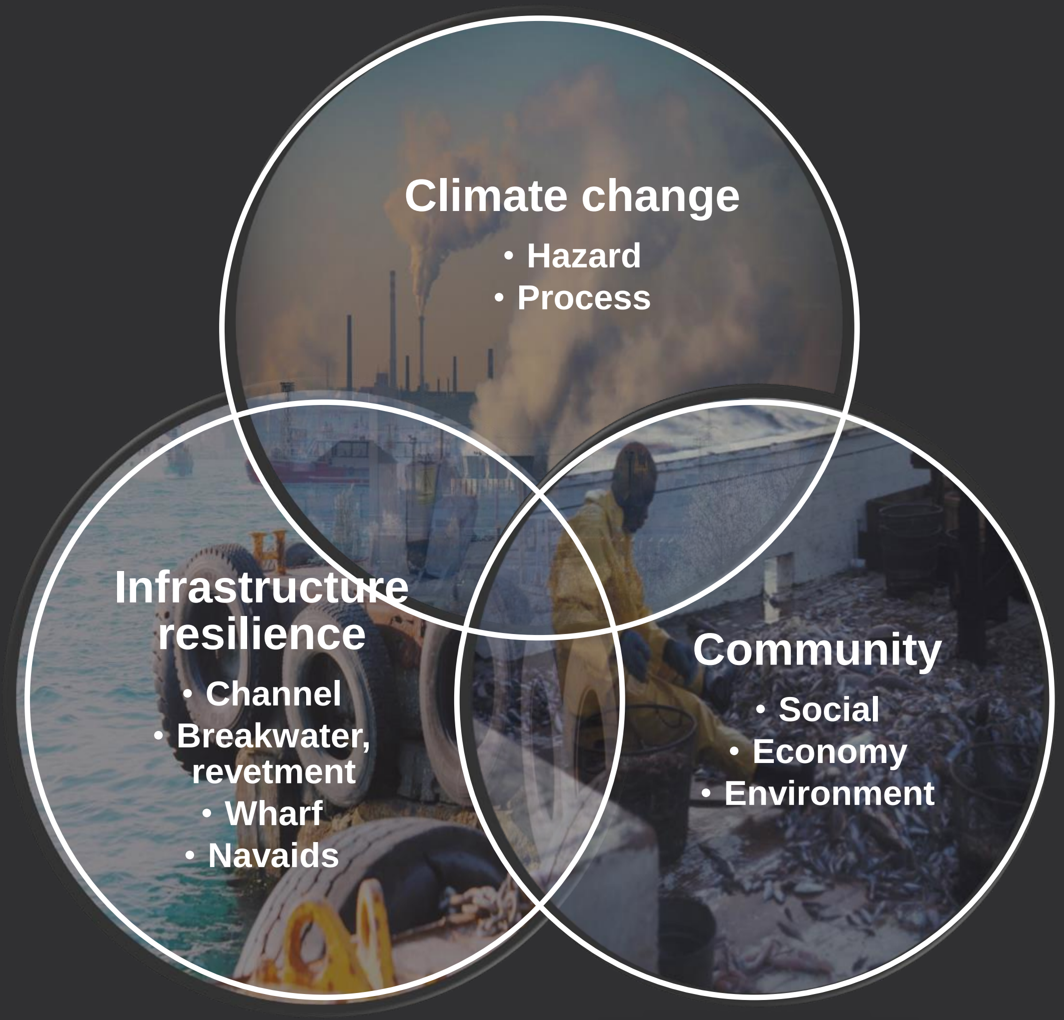
Why?

- Australian Sustainable Finance Roadmap – June 2024
- Australia Senate Passes New Mandatory Climate Disclosure Law – August 2024
- Australian Auditing and Assurance Board is developing assurance standards for climate disclosures – late 2024
- Best practice guidance for the disclosure of corporate transition plans - 2025

Purpose:

- labels for sustainable investment
- Monitor and address greenwashing
- Identify climate-related finance risks for banks insurer and superfunds

Interplay



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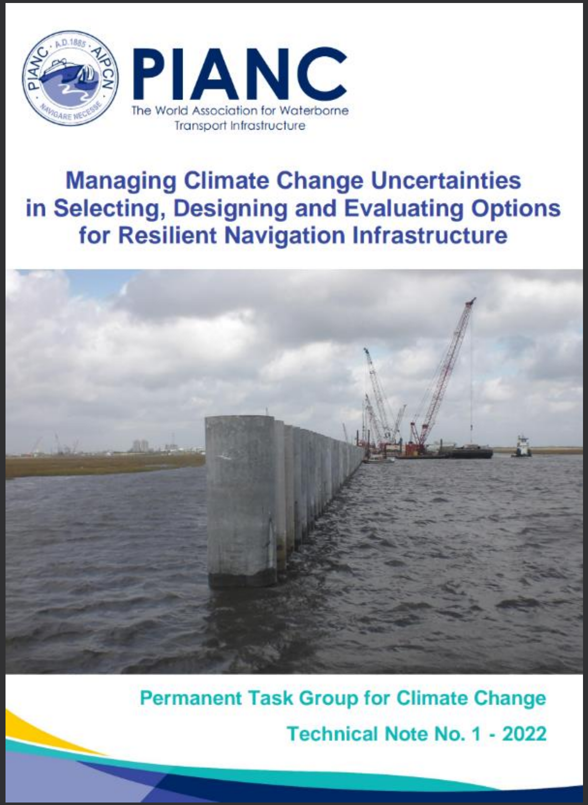
Credit: UnSplash, NOAA

Five Phases process

- Phase 1 – Climate Risk Screening
- Phase 2 – Initial Analysis
- Phase 3 – Climate Stress Test
- Phase 4 – Climate Risk Management
- Phase 5 – Monitoring, Evaluation and Reporting.

Phase 1 – Screening, identification

- Identify risk and opportunities
- Identify uncertainties
- Select Climate Scenario
- Select Approach



3-Tiers resilience assessment

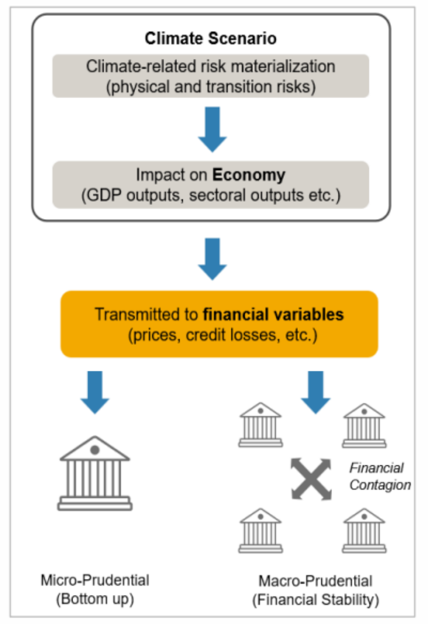
- Level 1 – Limited
  - Conceptual model, simple spreadsheet, etc.
- Level 2 – Semi-comprehensive
  - Calibration, downscaled model, typically bivariate
- Level 3 – Comprehensive
  - Ensemble modelling, stochastic, multivariate

Phase 2 – quantitative analysis

- Data collection and analysis
- Outline baseline scenario, set KPI
- Define approach for stress testing
- Stakeholder engagement

Phase 3 – Stress Testing

Financial



Climate stress testing.

MathWork®

vs

Infrastructure

Climate Model

Process-based models

Infrastructure performance

Economic Model

Climatic Data → Physical Parameters → Infrastructure reliability → Economic Performance

Phase 3 – preliminary approach

PARAMETERS / TIER	wave and coastal hydrodynamics processes	flooding and overtopping processes	Hydrology and river hydraulics processes	Sediment transport processes	Climate scenario Selection	Infrastructure Reliability	Stress test
Limited	Regression model for extreme waves and water levels	Overtopping formula and guidelines	Regression model Empirical methods Flood frequency analysis	Regression model Regional Sediment transport budget	Observed trend and AR6 regional trends	key performance indicators such as averaged and peak infrastructure utilisation, occupancy at set planning horizons	Uni or bivariate sensitivity analysis of wave and sea level for PMCF with PMP variation
Semi-Comprehensive	Third-generation spectral wave model with refraction and diffraction and 2D hydrodynamic modelling	Neural Network Overtopping Manual for combined wave and peak water level for each scenario	Seasonal hydrological model and flood frequency analysis supported by modelling PMF simulations	Interannual littoral transport at daily temporal scale, erosion empirical model	At least 3x credible GCM-based climate projections – optimistic, central, pessimistic, with 10th, 40th and 90th values	Key performance indicators evaluated at decadal level with evaluation of process interdependencies	Uni or bivariate sensitivity analysis of wave and sea level for PMCF with PMP variation
Comprehensive	3D phase resolving wave model and 3D hydrodynamic modelling	Computational Fluid Dynamic and physical testing for critical scenario	Event-based hydrological model and flood frequency analysis supported by numerical simulation. PMF simulation based on statistical and meteorological PMP	Coupled wave and hydrodynamic 3D model for storm and decadal shoreline evolution models	Credible RCM-based climate projections – optimistic, central, pessimistic, with 5th, 50th and 95th values and downscaled storm sequences	Event-based and long-term Monte-Carlo simulations with process interaction for infrastructure whole of life, including upgrade and maintenance operations	Multivariate sensitivity analysis of at least sea level rise and directional wave energy tensors in mean and extreme

Phase 4 – Climate Risk Management

- Identify resilience measures
- Consider infrastructure response - design optimisation
- Analyse resilience with optimised design
- Engage with stakeholders to determine management responses
- Compile climate risk management plan

Phase 5 – Monitoring, Evaluation and reporting

- Stakeholder evaluation
- Climate resilience monitoring plan
- Evaluation and re-assessment of climatic risk

Conclusion

Stress testing assess infrastructure resilience, identify critical weak points, and devise adaptive strategies to enhance waterborne infrastructure resilience.

Stress testing simulates “what if” scenarios beyond prescriptive standards, revealing hidden vulnerabilities and weaknesses that might not surface in risk assessments.

Analysing interplays and modelling “pragmatic” optimisation scenario allow to identify “no regret” adaptation measures and management responses. Stress testing scaffolds a resilient culture.