

Climate driven sea-level rise risk to port infrastructure: application to Portsmouth Port, UK

Prithviraj, P Jadhav, MSc
Brunel University London, UK

Miltiadis, Kontogeorgos, Civil Engineering Consultant
RINA Consulting S.p.A, Italy

Stergios, Aristoteles Mitoulis, Professor
The Bartlett School of Sustainable Construction, UCL, UK

Sotirios, Argyroudis, Associate Professor
Brunel University London, UK

Correspondence to: sotirios.argyroudis@brunel.ac.uk

1 INTRODUCTION & SCOPE OF WORK

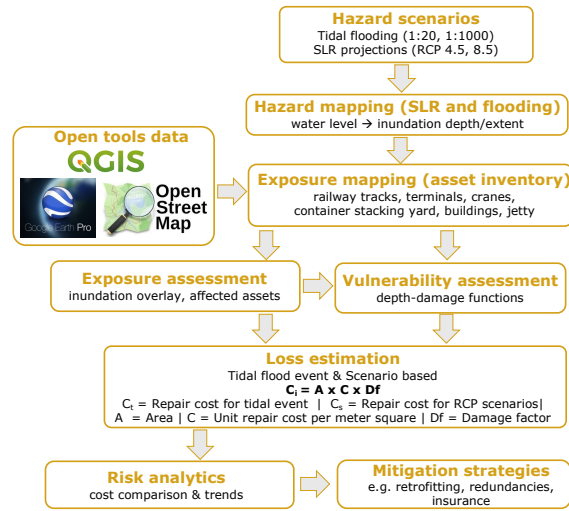
Flooding, overtopping, and damage have important implications for operations, supply chains, and regional economies. Ports are particularly vulnerable due to their combination of fixed coastal assets, transport links, and interdependent operational systems. Historical events demonstrate the scale of these risks, while future sea-level rise is expected to amplify the frequency and consequences of extreme coastal flooding (Elneel et al., 2023; Monioudi et al., 2025; Verschuur et al., 2023). There is therefore a need for infrastructure-level assessments that distinguish among asset types and support risk-informed adaptation planning. This extended abstract presents an application to Portsmouth Port, a low-lying coastal hub on the southern coast of the United Kingdom supporting commuter traffic, naval activity, and commercial shipping (Apostolakis et al., 2015). The study estimates potential repair costs for representative port assets under extreme tidal flooding and long-term sea-level rise scenarios. The analysis focuses on selected infrastructure assets, while recognising the potential for cascading disruption across interconnected port operations (Odeyemi et al., 2023).

2 METHODOLOGY

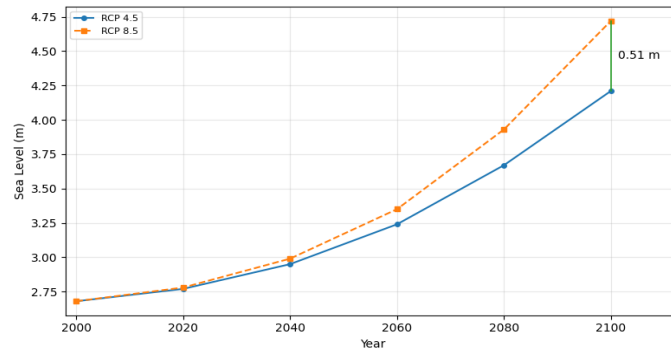
The assessment combines hazard analysis, exposure mapping, vulnerability characterisation, and economic evaluation. Hazard scenarios include extreme tidal flooding events with 1-in-20-year and 1-in-1000-year return periods, derived from Portsmouth-specific water-level estimates (Atkins, 2007), together with sea-level rise projections under RCP 4.5 and RCP 8.5 from UKCP18 (2018). Sea-level rise projections were combined with extreme tidal water levels to derive future flood levels. Exposure mapping and analysis were carried out using GIS-based tools and open-access spatial and elevation data, with asset location, extent, and general structural characteristics used to estimate flood exposure. The assessed asset portfolio includes operational, coastal, and transport-related infrastructure, with the ship repair structure (128,062 m²) and crane/container stacking area (121,862 m²) representing the largest exposed assets. Vulnerability was represented through published depth-damage relationships for different infrastructure classes, allowing inundation depth to be translated into expected damage levels (Habermann and Hedel, 2018). Repair costs were then estimated by linking inundation depth, damage factor, asset area, and representative unit cost values (Figure 1b). This enabled comparison of repair-cost trajectories across the selected port assets under both tidal and climate-change scenarios.



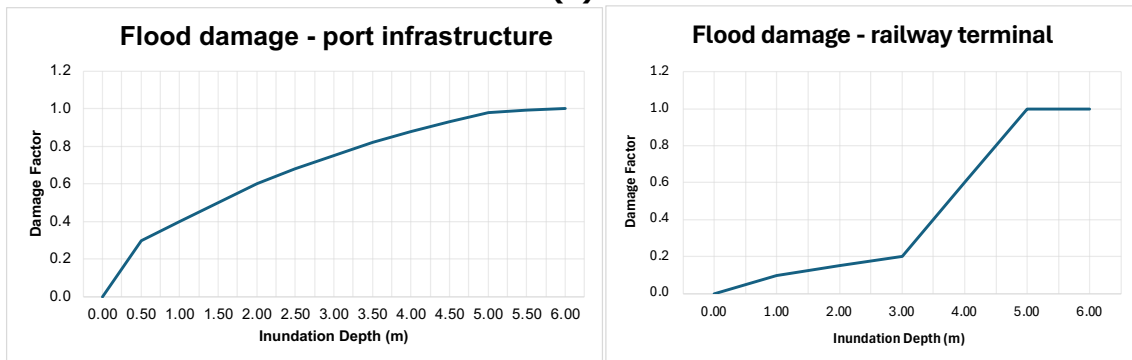
(a)



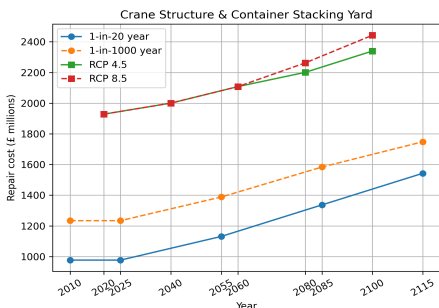
(b)



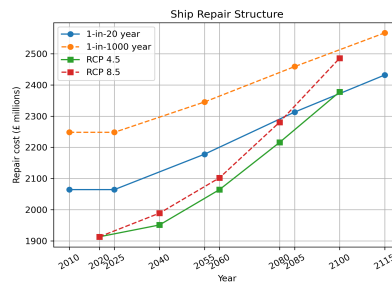
(c)



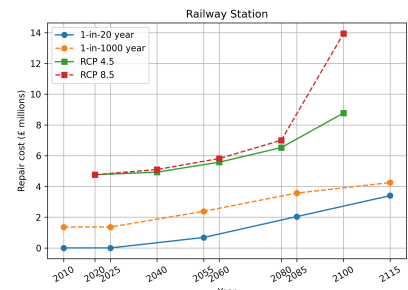
(d)



(e)



(f)



(g)

Figure 1. Synthesis of the study: (a) Portsmouth Port and key infrastructure assets, (b) methodological workflow linking hazard scenarios, GIS-based exposure mapping and analysis, depth-damage vulnerability modelling, and scenario-based loss estimation for port infrastructure, (c) projected sea-level rise under RCP 4.5 and RCP 8.5, (d) flood damage functions for port infrastructure (Habermann and Hedel, 2018) and (e-g) projected repair costs for representative infrastructure under tidal flooding and sea-level rise scenarios.

A practical strength of the approach is that it can be implemented with accessible data and software, making it transferable to ports where detailed inventories are not readily available. Uncertainties remain regarding data resolution, asset condition and simplified representation of local protection measures. Despite the limitations, the method provides a transparent basis for screening-level assessment and prioritising assets for more detailed investigation.

3 OUTCOMES

Figure 1 presents the study area, methodological workflow, sea-level rise scenarios, and representative repair-cost results. Extreme tidal water levels increase from 2.8 to 4.0 m for the 1-in-20-year event and from 3.3 to 4.5 m for the 1-in-1000-year event, indicating progressively greater exposure over time. Repair costs increase across all infrastructure categories as water levels rise and flood exposure intensifies. In all cases, the 1-in-1000-year event produces higher losses than the 1-in-20-year event, while RCP 8.5 results in greater future repair costs than RCP 4.5, with the divergence becoming more pronounced towards the end of the century. The ship repair structure and crane/container stacking yard emerge as the most exposed assets due to their large spatial extent and operational importance, whereas railway and transport assets show lower absolute losses but remain critical due to potential disruption across port operations.

Overall, the results highlight increasing economic risk and the potential for cascading impacts across interconnected infrastructure systems. The study demonstrates that accessible data and simplified methods can support screening-level assessment and prioritisation of assets for adaptation, particularly in data-constrained environments. From a practical perspective, adaptation planning should prioritise large, critical assets while accounting for indirect disruption. Measures such as elevating assets, improving drainage, integrating climate risk into maintenance, and adopting insurance mechanisms could reduce future losses.

ACKNOWLEDGEMENTS

SA and SM would like to acknowledge funding by the EU HORIZON [GA No: 101236476] PORTAL-Adaptive strategies for enhancing threat-agnostic resilience of port ecosystems

REFERENCES

- Apostolakis, A., Jaffry, S., Sizeland, F. and Cox, A. (2015). The role of uniqueness in destination branding: the case of historical Portsmouth harbor. *EuroMed J Business*, 10(2).
- Atkins (2007). Strategic flood risk assessment. Final report. Partnership for Urban South Hampshire.
- Elneel, L., Zitouni, M. S., Mukhtar, H., Galli, P., & Al-Ahmad, H. (2024). Exploring key aspects of sea level rise and their implications: An overview. *Water*, 16(3), 388.
- Habermann, N. and Hedel, R. (2018). Damage functions for transport infrastructure. *International Journal of Disaster Resilience in the Built Environment*, 9(4-5), 420–434.
- Monioudi, I.N., Vousedoukas, M.I., Giardino, A., Alessandro Stocchino, M., Mentaschi, L. and Feyen, L. (2025). Impacts of sea level rise and adaptation across Asia and the Pacific. *Scientific Reports*, 15(1).
- Odeyemi, S.O., Fontana, D., Ichi, E., Ajonye, E.S. and Alu, O. (2023). Assessing coastal areas' vulnerability to storm surge and flood: GIS and remote sensing approach. *J of Geosciences and Geomatics*, 11(3), 79–87.
- UKCP18 (2018). UK Climate Projections 2018: Marine Report. Met Office Hadley Centre.
- Verschuur, J., Koks, E.E., Li, S., Hall, J.W. (2023). Multi-hazard risk to global port infrastructure and resulting trade and logistics losses. *Comms Earth Environment*, 4, 1–12.