Interactions between human and non-human actors in coastal infrastructure projects

Annika Burkhardt[1], Aaron Opdyke[1], Nader Naderpajouh[2] and Abbas El-Zein[1]

[1] School of Civil Engineering, The University of Sydney, Sydney, Australia
[2] School of Project Management, The University of Sydney, Sydney, Australia

Research Problem Statement or Purpose

Climate change is increasing the exposure and vulnerability of coastal communities (Huynh et al., 2024; Morris et al., 2018; Steven et al., 2023). More than 40% of the global population currently lives along coastlines, and approximately 75% lives within 50km of a coastline (Huynh et al., 2024; Steven et al., 2023). These numbers are projected to grow in the coming decades (Huynh et al., 2024; OECD, 2018; Steven et al., 2023; Sutton-Grier et al., 2015). The Asia-Pacific region is considered at risk from climate-induced natural hazards, with the top three countries in the 2024 World Risk Index (the Philippines, Indonesia, and India) all from the region. Many of these people live in low-lying coastal areas, which are projected to be especially impacted by sea level rise (Bündnis Entwicklung Hilft / IFHV, 2024; Sunkur et al., 2023). There is thus a growing need to implement coastal solutions that adequately support the adaptation of these communities to the changing climate.

Traditionally, there has been a preference for utilising grey infrastructure, such as seawalls or dikes, to protect from coastal flooding – related to their long use history and a phenomenon called path dependency, leading to the implementation of familiar and 'proven' solutions (Powell et al., 2019; Seddon et al., 2019). However, increasing criticism, such as negative impacts on coastal ecosystems and increasing maintenance costs under the difficult task of adapting these structures to sea level rise (SLR), have led to an increasing focus on alternative solutions, such as hybrid or green infrastructure, often conjointly referred to as nature-based solutions (NbS), including living shorelines, mangroves and artificial reefs (Fernandes & Guiomar, 2018; Kuwae & Crooks, 2021; Matsushima & Zhong, 2022; Peck et al., 2022; Van Zelst et al., 2021). This evolving shift highlights that the selection, design and implementation of coastal infrastructure are shaped by a range of interacting actors. These include human actors and stakeholders, such as government agencies and communities, as well as non-human actors, such as ecosystems, funding, and existing infrastructure systems, which are often less formally recognised in processes.

Coastal infrastructure projects are widely considered most likely to be 'successful' when "they meet the needs of those who live there" (Lucatello & Alcántara-Ayala, 2024, p. 6). In practice, however, coastal infrastructure projects often fail to meet sustainability targets, commonly due to governance barriers and persistent shortcomings in stakeholder engagement (Anisimov et al., 2020; Junqueira, 2016). Existing research highlights issues in stakeholder engagement, with critiques of tokenistic participation and late-stage consultation (Palinkas et al., 2022; Schuerch et al., 2022). However, much of the existing literature assumes rather than interrogates who or what is recognised as a stakeholder, or more broadly, an actor in coastal infrastructure projects.

This shows there is a critical gap in understanding who or what the actors are in coastal infrastructure projects, how they are included, prioritised, and excluded in decision-

making processes, and how this influences climate change adaptation outcomes. This research thus analyses the actors, both human and non-human, that influence coastal infrastructure projects in the Philippines, and how their interactions shape decision-making processes.

This research is the first part of a larger analysis aimed at understanding the impact of stakeholder engagement, leadership practices, and institutional arrangements on decision-making processes in coastal infrastructure projects in the Philippines and, in later stages, also in Australia.

Research Methodology and Approach

This research adopted a case study approach to enable in-depth investigation of contextual realities (Noor, 2008). Theoretically, this chapter draws on Actor-Network Theory (ANT) (Callon, 1984; Latour, 2005) to expand the notion of stakeholders beyond human agents. Actor-Network Theory can be understood as a framework in social theory that follows that both humans and non-humans can represent actors within a network, bridging conventional distinctions between society, nature and technology (O'Doherty, 2019). Infrastructure projects mobilise diverse actants, including plants, microorganisms, digital technologies, and hydrological forces. These actors are expected to play a role in co-producing adaptation outcomes by shaping how climate adaptation is defined and experienced. ANT provides a relational lens to trace these interactions and better understand how adaptation and maladaptation emerge through the alignment, or misalignment, of these elements.

Data was collected through 18 semi-structured interviews in the English language, lasting between 45 and 120 min, that were conducted in January-February 2026 in the Philippines (Reed et al., 2009). Interviewees included academic scholars, project managers, coastal engineers, disaster risk reduction and climate change adaptation specialists and funding agencies. Key informants were chosen based on their roles and knowledge of the projects (Lokot, 2021). The Philippines provides a compelling case for this research due to its exposure to flooding and its high concentration of coastal cities (Brower et al., 2014). Questions focused on actors in coastal infrastructure projects, including if any unexpected actors arose and their relational dynamics. ANT was used as a theoretical lens for data analysis, enabling coding of instances in which interviewees mentioned non-human actors and relational aspects among different stakeholders and actors. Qualitative data analysis, including steps of data preparation, organisation and reduction through coding into themes, was used to analyse the data (Creswell, 2007). The coding was based on an abductive approach, which allowed for some pre-determined codes, while still allowing new codes and themes to emerge from the interview data (Graneheim et al., 2017; Hsieh & Shanon, 2005).

This research is part of a larger project that will expand this dataset through additional interviews and focus groups with community members in project areas, and document analysis, followed by actor-linkage matrices, to investigate the relationships between the actors and will include a comparative case with Australia (Reed et al., 2009).

Key Findings

Overall, the interviews revealed that decision-making in coastal infrastructure projects is largely shaped by interactions, often subconsciously, between human and non-human actors rather than by technical considerations alone. A preference for grey infrastructure, with interviewees mentioning that "the automatic response (…) is to build a dike", was a dominant theme and closely related to anecdotes on established procurement systems and engineering university curricula. This shows that existing infrastructure, common practices, and systems shape future decisions, and can thus be considered actors in the system, closely interacting with human actors in the decision-making process. Broader governance issues, such as short political cycles, funding-related aspects and fragmented governance, were furthermore found to foster reactive and short-term decision-making, further leading to a path dependency of implementing grey infrastructure, where disasters were considered catalysts or triggers for investments: "after the disaster (…) they started doing some projects".

While a variety of human actors were identified as key players, including the national government, donor agencies and local government units, the communities where coastal infrastructure is implemented were described as not being involved in or excluded from the decision-making processes: "maybe 95% of them will say 'we were not involved, we just suddenly saw this dyke being built here'". This, as several interviewees noted, risks maladaptive project outcomes if the needs and livelihoods of those affected by projects are not considered. This shows the need to better understand how interactions among both human and non-human actors shape the climate change adaptation outcomes of coastal infrastructure projects.

Implications

This research has implications for both theory and practice in climate adaptation and coastal infrastructure planning.

Theoretically, the findings of this research challenge conventional stakeholder frameworks by demonstrating the importance of including non-human actors, such as infrastructures, funding arrangements, and ecosystems, in decision-making. Recognising the role these actors play in decision-making processes provides a more holistic understanding of how adaptation outcomes are produced and why certain infrastructures may persist despite known limitations. While initial steps towards this are being taken, for instance, through environmental impact assessments, more explicit acknowledgement of non-human actors as part of the established actors in projects may lead to more equitable, sustainable, just, and resilient outcomes.

More broadly, this study highlights the need for a more holistic system lens when analysing adaptation outcomes in coastal infrastructure projects, including how fragmented institutional arrangements, short political cycles and existing infrastructures shape future decisions. Making these dynamics more visible can help policymakers and decision-makers identify where interventions are needed to shift current decision-making pathways.

Funding

This work is funded by the John Grill Institute for Project Leadership.

References

Anisimov, A., Magnan, A. K., & Duvat, V. K. E. (2020). Learning from risk reduction pilot projects for enhancing long-term adaptation governance: The case of Mauritius Island (Indian Ocean). *Environmental Science and Policy*, *108*, 93–103. Scopus. https://doi.org/10.1016/j.envsci.2020.03.016

Brower, R. S., Magno, F. A., & Dilling, J. (2014). Evolving and implementing a new disaster management paradigm: the case of the Philippines. In Springer eBooks (pp. 289–313). https://doi.org/10.1007/978-3-319-04468-2_17

Bündnis Entwicklung Hilft / IFHV. (2024). *WeltRisikoBericht 2024*. https://entwicklung-hilft.de/wp-content/uploads/2025/02/WRB_2024_Bericht_online.pdf

Callon, M. (1984). Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay. *The Sociological Review*, *32*(1_suppl), 196–233. https://doi.org/10.1111/j.1467-954X.1984.tb00113.x

Creswell, J. W. (2007). *Qualitative inquiry & research design: Choosing among five approaches* (2nd ed). Sage publ.

Fernandes, J. P., & Guiomar, N. (2018). Nature-based solutions: The need to increase the knowledge on their potentialities and limits. *Land Degradation & Development*, *29*(6), 1925–1939. https://doi.org/10.1002/ldr.2935

Graneheim, U. H., Lindgren, B.-M., & Lundman, B. (2017). Methodological challenges in qualitative content analysis: A discussion paper. *Nurse Education Today*, 56, 29–34. https://doi.org/10.1016/j.nedt.2017.06.002

Hsieh, H.-F., & Shanon, S. (2005). *Three Approaches to Qualitative Content Analysis*. https://doi.org/10.1177/1049732305276687

Huynh, L. T. M., Su, J., Wang, Q., Stringer, L. C., Switzer, A. D., & Gasparatos, A. (2024). Meta-analysis indicates better climate adaptation and mitigation performance of hybrid engineering-natural coastal defence measures. *Nature Communications*, *15*(1), 2870. https://doi.org/10.1038/s41467-024-46970-w

Junqueira, L. E. (2016). *Success and Failure of Infrastructure Construction Projects—The Brazilian Reality*. Swiss Business School.

Kuwae, T., & Crooks, S. (2021). Linking climate change mitigation and adaptation through coastal green-gray infrastructure: A perspective. *Coastal Engineering Journal*. https://doi.org/10.1080/21664250.2021.1935581

Latour, B. (2005). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford University Press. https://doi.org/10.1093/oso/9780199256044.001.0001

Lokot, M. (2021). Whose Voices? Whose Knowledge? A Feminist Analysis of the Value of Key Informant Interviews. *International Journal of Qualitative Methods*, *20*, 1609406920948775. https://doi.org/10.1177/1609406920948775

Lucatello, S., & Alcántara-Ayala, I. (2024). Sustainable Synergy: Strengthening disaster risk reduction in Latin America and the Caribbean through nature-based solutions. *International Journal of Disaster Risk Reduction*, *113*, 104860. https://doi.org/10.1016/j.ijdrr.2024.104860

Matsushima, H., & Zhong, X. (2022). Challenging a Hybrid Between Green and Gray Infrastructure: Coastal Sand-Covered Embankments. In F. Nakamura (Ed.), *Green Infrastructure and Climate Change Adaptation* (pp. 323–334). Springer Nature Singapore. https://doi.org/10.1007/978-981-16-6791-6_20

Morris, R. L., Konlechner, T. M., Ghisalberti, M., & Swearer, S. E. (2018). From grey to green: Efficacy of eco-engineering solutions for nature-based coastal defence. *Global Change Biology*, *24*(5), 1827–1842. https://doi.org/10.1111/gcb.14063

Noor, K. B. M. (2008). Case Study: A Strategic Research Methodology. *American Journal of Applied Sciences*, *5*(11), 1602–1604. https://doi.org/10.3844/ajassp.2008.1602.1604

O'Doherty, D. (2019). Actor-network theory: Michel Callon, Bruno Latour, John Law. In *Management, Organizations and Contemporary Social Theory*. Routledge.

OECD. (2018). *Innovative Approaches to Building Resilient Coastal Infrastructure* (OECD Environment Policy Papers No. 13; OECD Environment Policy Papers, Vol. 13). https://doi.org/10.1787/9c8a13a0-en

Palinkas, C. M., Orton, P., Hummel, M. A., Nardin, W., Sutton-Grier, A. E., Harris, L., Gray, M., Li, M., Ball, D., Burks-Copes, K., Davlasheridze, M., Schipper, M. D., George, D. A., Halsing, D., Maglio, C., Marrone, J., McKay, S. K., Nutters, H., Orff, K., … Williams, T. (2022). Innovations in Coastline Management With Natural and Nature-Based Features (NNBF): Lessons Learned From Three Case Studies. *Frontiers in Built Environment*, *8*. https://doi.org/10.3389/fbuil.2022.814180

Peck, A., Adams, S., Armstrong, A., Bartlett, A., Bortman, M., Branco, A., Brown, M., Donohue, J., Kodis, M., McCann, M., & Smith, E. (2022). A new framework for flood adaptation: Introducing the Flood Adaptation Hierarchy. *Ecology and Society*, *27*(4), art5. https://doi.org/10.5751/ES-13544-270405

Powell, E. J., Tyrrell, M. C., Milliken, A., Tirpak, J. M., & Staudinger, M. D. (2019). A review of coastal management approaches to support the integration of ecological and human community planning for climate change. *Journal of Coastal Conservation*, *23*(1), 1–18. https://doi.org/10.1007/s11852-018-0632-y

Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C. H., & Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, *90*(5), 1933–1949. https://doi.org/10.1016/j.jenvman.2009.01.001

Schuerch, M., Mossman, H. L., Moore, H. E., Christie, E., & Kiesel, J. (2022). Invited perspectives: Managed realignment as a solution to mitigate coastal flood risks—Optimizing success through knowledge co-production. *Natural Hazards and Earth System Sciences*, *22*(9), 2879–2890. Scopus. https://doi.org/10.5194/nhess-22-2879-2022

Seddon, N., Chausson, A., Berry, P., Girardin, C., Smith, A., & Turner, B. (2019). *Understanding the value and limits of nature-based solutions to climate change and other global challenges*. https://doi.org/10.1098/rstb.2019.0120

Steven, A., Addo, K. A., Llewellyn, G., Ca, V. T., Boateng, I., Bustamante, R., Doropoulos, C., Gillies, C., Hemer, M., Lopes, P., Kairo, J., Rahman, M., Ravaoarinorotsihoarana, L. A., Saunders, M., Sumaila, U. R., Sidik, F., Teh, L., Vanderklift, M., & Vozzo, M. (2023). Coastal Development: Resilience, Restoration and Infrastructure Requirements. In J. Lubchenco & P. M. Haugan (Eds.), *The Blue Compendium* (pp. 213–277). Springer International Publishing. https://doi.org/10.1007/978-3-031-16277-0_7

Sunkur, R., Kantamaneni, K., Bokhoree, C., & Ravan, S. (2023). Mangroves' role in supporting ecosystem-based techniques to reduce disaster risk and adapt to

climate change: A review. *Journal of Sea Research*, *196*. Scopus. https://doi.org/10.1016/j.seares.2023.102449

Sutton-Grier, A. E., Wowk, K., & Bamford, H. (2015). Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems. *Environmental Science & Policy*, *51*, 137–148. https://doi.org/10.1016/j.envsci.2015.04.006

Van Zelst, V. T. M., Dijkstra, J. T., Van Wesenbeeck, B. K., Eilander, D., Morris, E. P., Winsemius, H. C., Ward, P. J., & De Vries, M. B. (2021). Cutting the costs of coastal protection by integrating vegetation in flood defences. *Nature Communications*, *12*(1), 6533. https://doi.org/10.1038/s41467-021-26887-4