Nature-Based Solutions (NBS) as Hazard Mitigation for Energy Security

Energy infrastructure in the United States faces risks due to the frequency and severity of natural hazards such as hurricanes and flooding. This can lead to the disruption of electricity, rising transmission and distribution costs, and cascading impacts on critical services and energy end-users. Analyzing risks to avoid disruptions to energy services is a critical function of energy security planning.

Common methods to mitigate weather-related hazards have centered around reducing the vulnerability of infrastructure to hazards by either hardening and protecting the infrastructure itself or building new, more robust facilities to replace existing ones – broadly known as strategies prioritizing "gray infrastructure" or "engineered solutions"[1]. Gray infrastructure can be effective and straightforward to implement. Still, these solutions are not the only options, and over the long lifespan of the infrastructure, hazard exposure will change. Alternative solutions can manage for varying exposure and expand day-to-day "blue sky" benefits to a broader range of stakeholders, beyond the owner of the asset or facility.

Nature-based solutions (NBS) are an underexplored mitigation option for public investment into ensuring energy security, de-risking energy disruptions and lowering costs. NBS are "actions to protect, sustainably manage, and restore natural capital or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits"[2]. These solutions can be restorative, protective, address specific issues, involve building infrastructure, or be management strategies[3] Given their ability to provide buffering capacity and their flexibility to mitigate a range of risks, NBS are often implemented as low-regrets investments to accommodate a range of possible trends and future hazards. To date, at the global scale, NBS have been predominantly applied in coastal, urban, and watershed management settings. International investments from Multilateral Development Banks (MDBs) have been key to their success, as they have provided structure and process to the approach by including NBS in their investment portfolios.

Nature-based solutions are part of a research investigation into available and emerging solutions for reducing risks to energy security. Findings of this research could help inform decision makers on alternatives that reduce the exposure of energy infrastructure to threats, while also providing larger benefits to society.

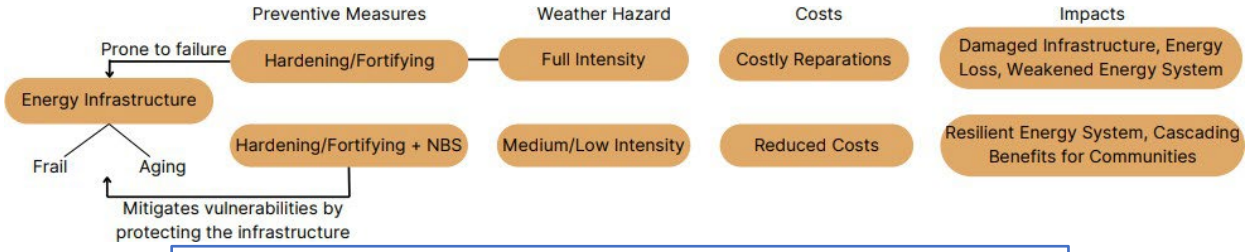

Figure 1. Pathways for reducing risks of natural hazards to energy infrastructure

1 Browder, G., Ozment, S., Rehberger Bescos, I., Gartner, T., & Lange, G.-M. (n.d.). *Integrating Green and Gray: Creating Next Generation Infrastructure*. World Bank and World Resources Institute. https://files.wri.org/d8/s3fs-public/integrating-green-gray_0.pdf?_gl=1*189b779*_gcl_au*MTk2NjExMDc1Ny4xNzMzOTQ3Nzg3

2 International Union for Conservation of Nature. (n.d.). *Defining Nature-based Solutions*. https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_RES_069_EN.pdf

3 Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., Maginnis, S., Maynard, S., Nelson, C. R., Renaud, F. G., Welling, R., & Walters, G. (2019). *Core principles for successfully implementing and upscaling Nature-based Solutions*. Environmental Science & Policy, *98*, 20–29. https://doi.org/10.1016/j.envsci.2019.04.014

Technical Gaps in NBS Application to Energy Security Risk Reduction

PNNL conducted an initial review of NBS literature and its applications and consulted with program managers to understand the current state of nature-based solutions for energy security.[4] In particular, PNNL investigated the intentional use of NBS to reduce the potential for natural hazards to disrupt energy operations or energy-enabling supply chains, with the following findings:

- NBS have largely been developed for water-related processes, specifically in coastal, watershed, and urban environments. There is an increasing interest in fire-related processes.
- NBS can address both direct and indirect impacts.
- NBS can respond adaptively to hazards over time.
- In energy, hydropower is one of the most prominent examples due to the direct reliance on natural processes (e.g. watershed sedimentation and erosion).

There are knowledge and practical gaps in the implementation of NBS for reducing risk to energy security. For example, data requirements to justify and then design NBS are often site-specific or local and difficult to extrapolate from site to site. Measurement and verification processes can take significant time.

While there is information on NBS-implemented projects, there is little available data on the relationship between NBS and its influence on ecosystem functions at a scale that is meaningful for risk reduction to energy infrastructure. Quantifying these effects is a challenge when planning NBS projects, due to the difficulties of measuring the effects empirically.

Future Research Recommendations

There is a need for a research investigation to explore and strengthen the relationship between energy security and NBS. The research should aim to analyze different options to reduce the risks posed by natural hazards to energy infrastructure and services, while assessing potential mechanisms to enable those approaches at various settings. In particular:

- Develop an NBS for Energy Security framework to clarify the opportunity for NBS to support energy security outcomes and inform risk assessment and mitigation.
- Provide a technical foundation for applying specific NBS to reduce risks to energy infrastructure, including modeling NBS interventions to reduce known hazards to critical energy infrastructure and reduce risks to energy security systems, such as outages.
- Analyze case studies for investments to develop more specific ranges for costs, benefits, timelines, and metrics, among other attributes.
- Develop stakeholder mapping to understand the range of benefits and beneficiaries associated with NBS for Energy Security.

The broader NBS research goal is to enhance the opportunity for all potentially cost-effective risk mitigation methods to be integrated into energy security analysis and decision-making, with mechanisms to compare investments, clarify outcomes, and broaden the beneficiaries as well as the solution providers in the field.

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