Model-based Lego Mix'n'match: Siting Nature-Based Solutions in Chesapeake Bay

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1. Introduction

Many different flavors of nature-based solutions (NbS) for coastal resilience are possible (Figure 1). How can performance expectations and coastal threat risk be coupled to plan the implementation of NbSs in coastal areas with complex hydrodynamics and ecosystem considerations (Figure 2)? Based on a recently completed project for the U.S.EPA in the town of Crisfield, Maryland on the Chesapeake Bay, we present a generalizable and scalable framework for scoping resilient coastal protection projects.

Figure 1. Typical nature-based solutions (from left to right): coir edging, marsh restoration with hydrologic connectivity, living breakwaters, dredge material beneficial use, oyster reefs, and beach and dune nourishment

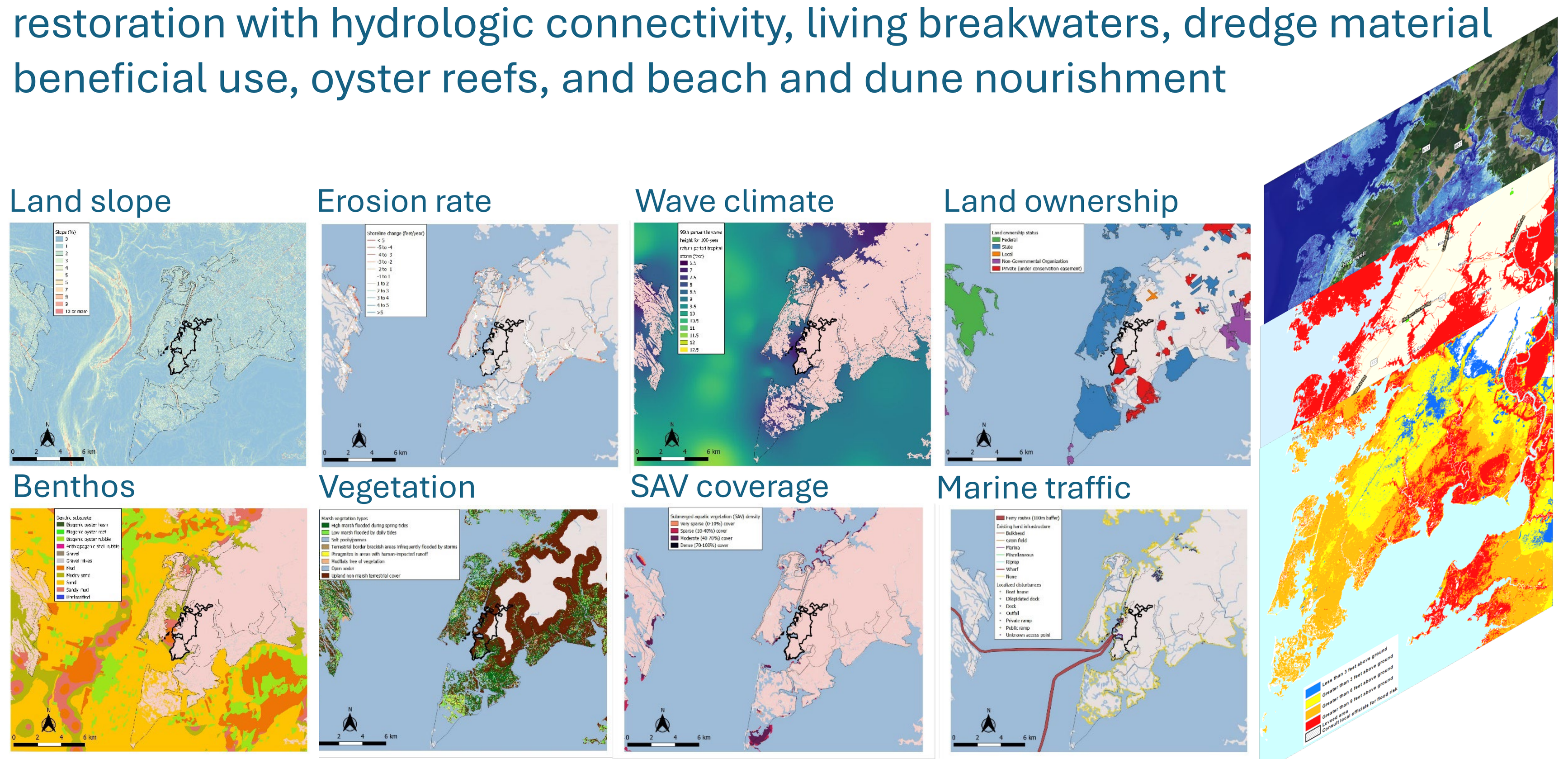

Figure 2. Typical environmental condition variables and risk profiles, such as sea level rise, sunny-day flooding, and surge inundation risk.

2. Approach

We first classified the marshlands and barrier islands around the town into thematic zones with similar threat profiles and environmental conditions. Then, by combining anticipated performance against various coastal threats with the prospective protections provided by different NbS alternatives and combinations of NbSs in a synthetic Monte Carlo Polling approach, we were able to rank candidate solutions and simulate the impacts of a small number of top-ranked solutions. In this approach, computerized expert agents ranked the proposed solutions by their ability to mitigate the risk profile given environmental conditions, and top-ranked solutions polled across 1,000 agents were selected.

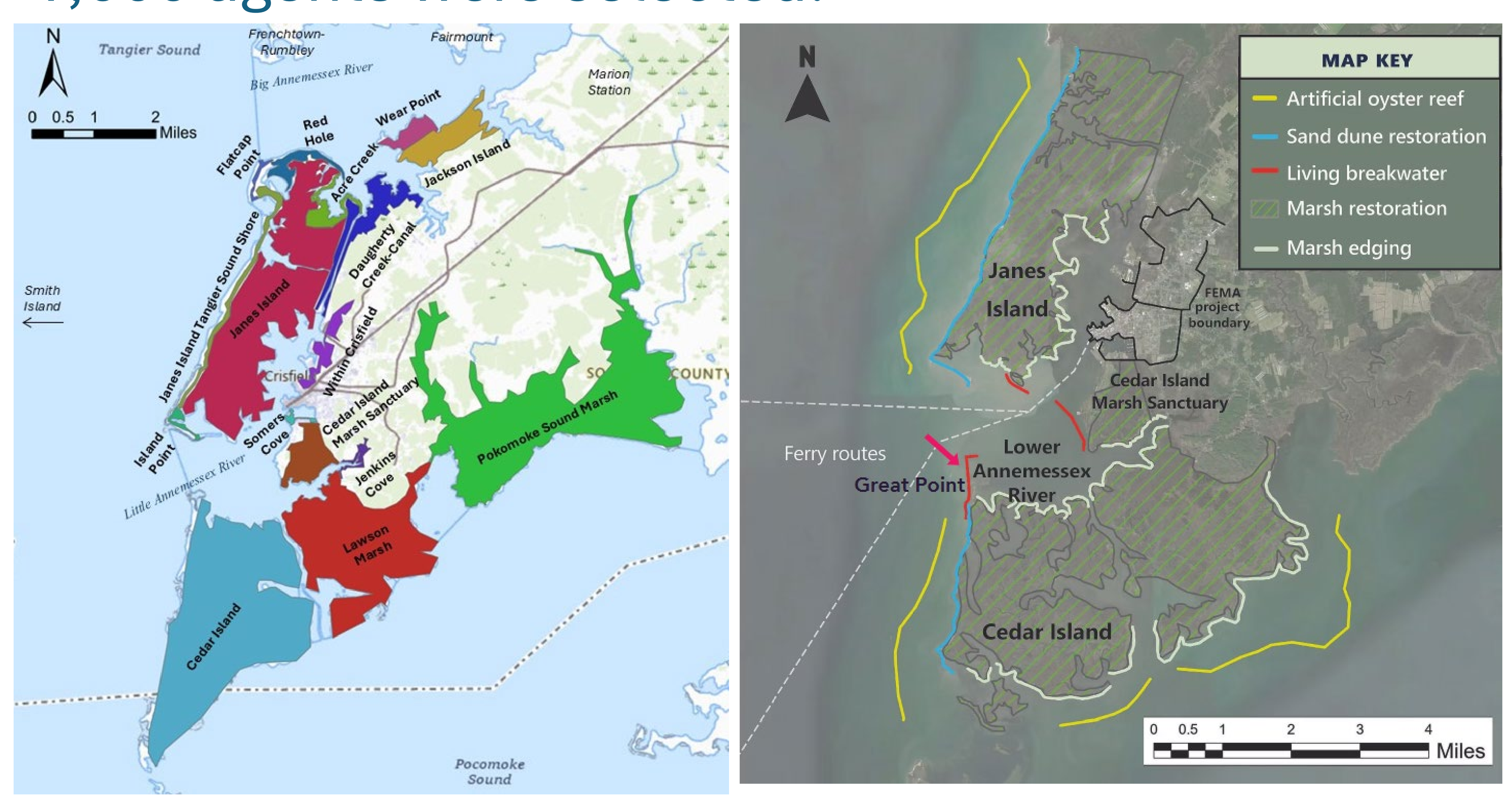

Figure 3. Thematically similar areas around the town (left), and top-ranked candidate solutions based on voting by synthetic "experts and stakeholders."

3. Modeling Expected Performance

We simulated how the top-ranked solutions would perform using Delft3D-FM and D-Wave, and investigated blue carbon sequestration benefits using InVEST (Figure 4). Based on these studies, we prioritized solutions to take to stakeholders for design funding (Figure 5).

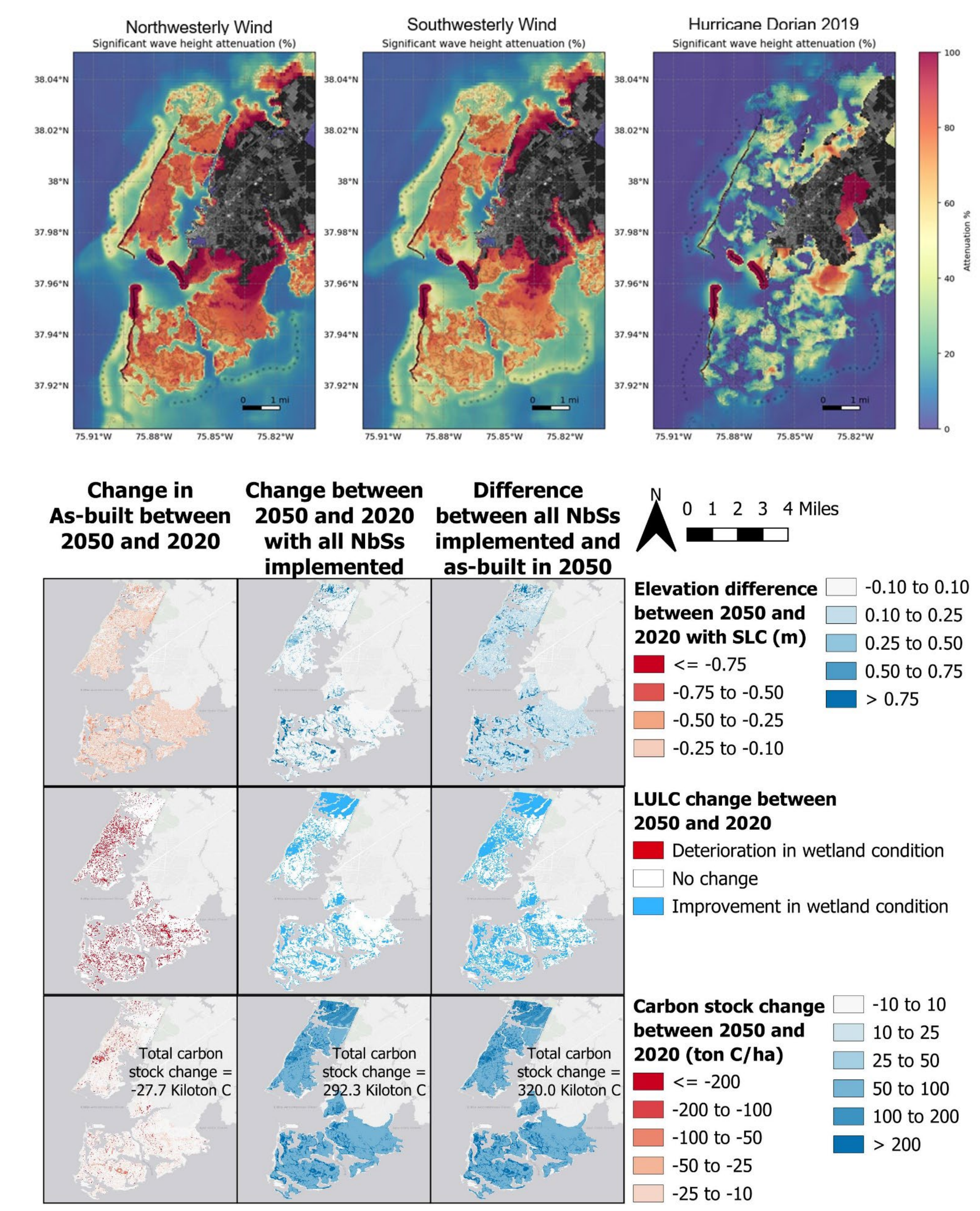

Figure 4. Wave attenuation under different wind conditions (top), and elevation change, land use change, and blue carbon sequestration potential by 2050 under sea level rise with nature-based solutions implemented.

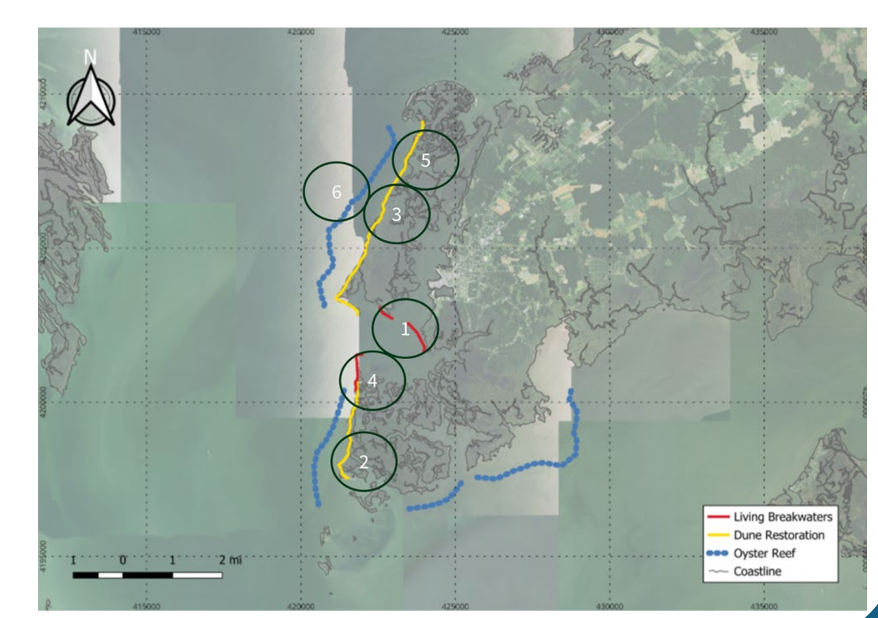

Figure 5. Prioritized top solutions for stakeholder engagement and future funding considerations

References

Tetra Tech, Inc. 2024. *Literature review of effectiveness of natural infrastructure for coastal resilience.* Fairfax, VA: Draft Report Submitted Under Chesapeake Bay Solutions Driven Research to the United States Environmental Protection Agency Office of Research and Development, 114p.

Tetra Tech, Inc. 2025a. *Simulation of storm surge and wave propagation at Crisfield (MD) during storm events considering different Nature-based Solutions (NbS).* Fairfax, VA: Draft Report Submitted Under Chesapeake Bay Solutions Driven Research to the United States Environmental Protection Agency Office of Research and Development, 147p.

Tetra Tech, Inc. 2025b. *Blue Carbon Modeling Report.* Fairfax, VA: Draft Report Submitted Under Chesapeake Bay Solutions Driven Research to the United States Environmental Protection Agency Office of Research and Development, 23p.