Advanced Modeling and Predictive Analytics of Resource Optimization: A Mixed Integer Programming Approach to Improve Oil Spill Response in Arctic Canada

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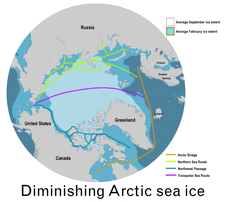
Introduction

Background



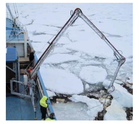
Diminishing Arctic sea ice opens shipping routes

Increased shipping

Shipping accident

Oil spill risk

Mechanical recovery



Dispersant application

In-situ burning

Purpose

- Respond to Arctic oil spills within predetermined time windo
- Serve sensitive areas with high priority
- Mitigate negative consequences

Contribution/ Significance

- Proposed a hierarchical multiobjective location allocation optimization model for maximum oil spill coverage
- Research gap on resource allocation centered on Arctic conditions is furnished
- An AI-based Mixed Integer Programming (MIP) can act as a Decision Support Tool, helping strategic decision-makers
- Compared with the current response facility setup and satisfactory results are found, demonstrated through network diagrams

Acknowledgement

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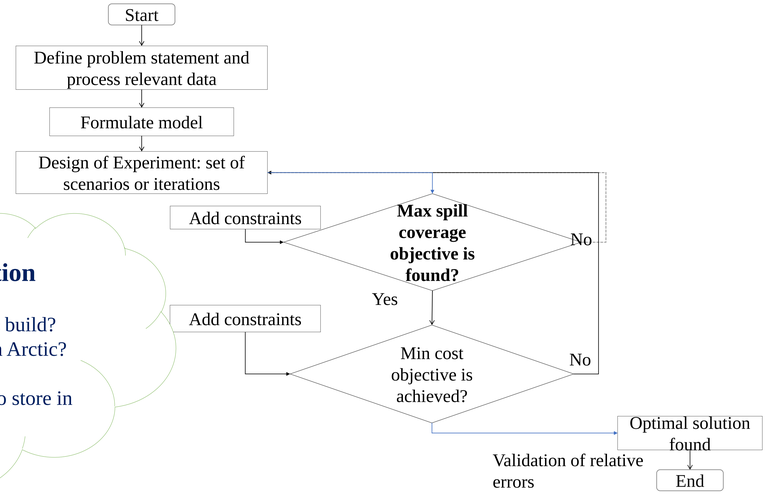
Research Question

Facility Location
- How many facilities to build?
- Where to build them in Arctic?

Resource Allocation
- How much resources to store in those facilities?

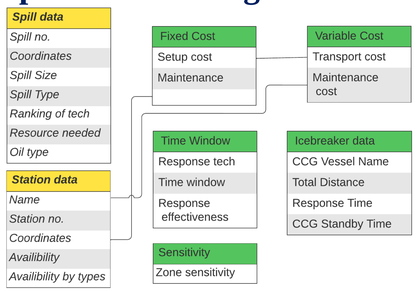
Method

Optimization Modeling Process Flow



This MIP model maximizes location coverage considering spill zone and environmental and cultural sensitivity coverage, minimizing response time for assets to arrive from response stations to spill zones within a time window

Experimental Design and Data



Solution

- Branch & Cut algorithm
- Gurobi optimization solver is used to find solutions

GUROBI OPTIMIZATION

python

Result

Current vs Proposed facility setup

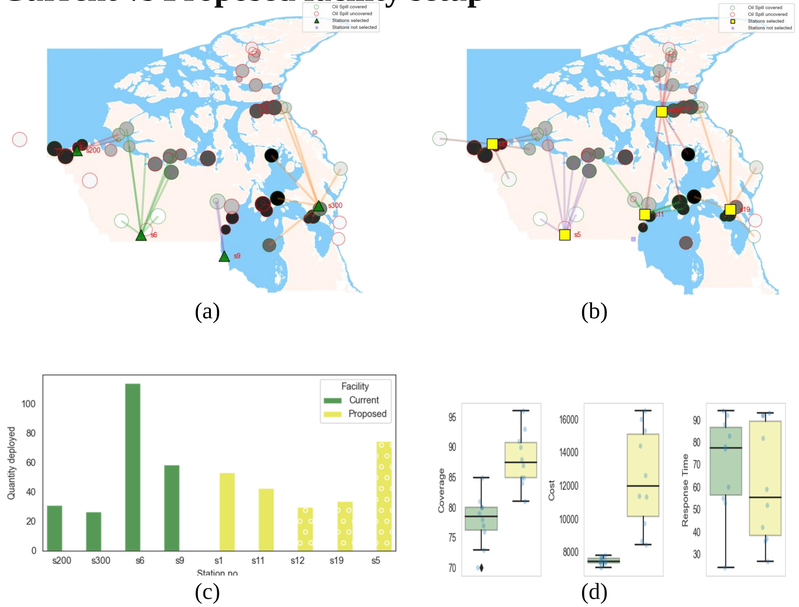


Fig3. (a) Network Diagram by current setup in Canadian Arctic (b) Proposed facility setup (Coverage enhanced from 49% to 78%, Improved response time) **(c)** Resource allocation (d) Comparing Performance

Engagement

Through end-user engagement and involvement of industry experts, the societal relevance and usefulness of research objectives and results are ensured.

ARCTIC COUNCIL

Transport Canada

Canadian Coast Guard

Reference

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[2] Das, T., & Goerlandt, F. (2022). Bayesian inference modeling to rank response technologies in arctic marine oil spills. Marine Pollution Bulletin, 185, 114203. https://doi.org/10.1016/j.marpolbul.2022.114203
[3] Das, T., Goerlandt, F., & Pelot, R. (2023). A Mixed Integer Programming Approach to Improve Oil Spill Resource Allocation in the Canadian Arctic. Journal of Risk & Reliability (Submitted).