

# Stochastic Benders Optimisation: Hurricane-Aware Warehousing in North-Eastern Nicaragua

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MIT – Integer Optimization (15.083)

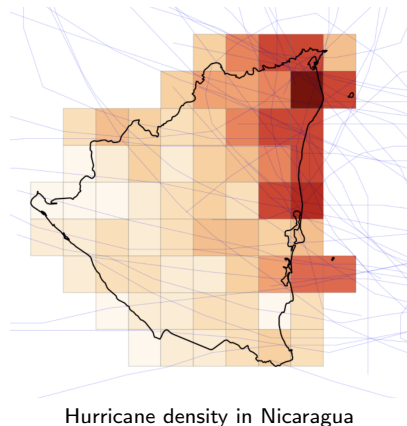
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# Data & Modelling Overview

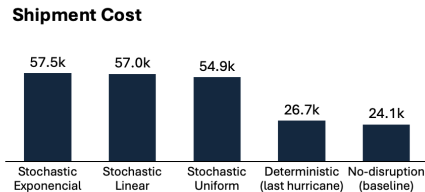
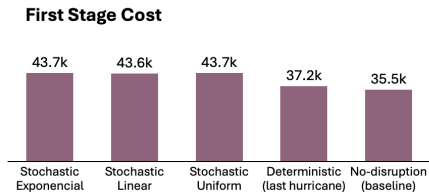
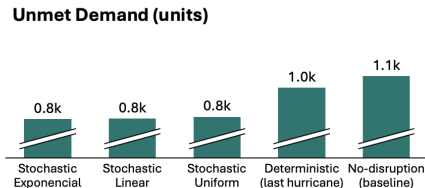
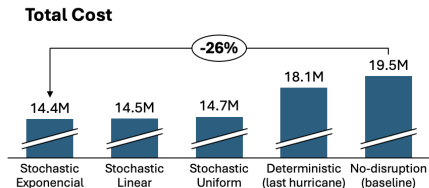
- Real data: 42 historical hurricanes, WorldPop, OSM roads & facilities
- Focus: NE Nicaragua (highest risk)
- Disruptions: Roads affected within 10 km; warehouses lose stock within 5 km
- **Two-stage stochastic MIP:**

$$\min_{f,r} \underbrace{\sum_i h_i f_i + c_r r_i}_{\text{open \& stock}} + \mathbb{E}_s \left[ \underbrace{\sum_{ij} c_{ijs} x_{ijs} + M u_{js}}_{\text{ship \& unmet}} \right]$$

- **Solver:** 4-thread Benders: 1.4 s < full MIP: 1.5 s

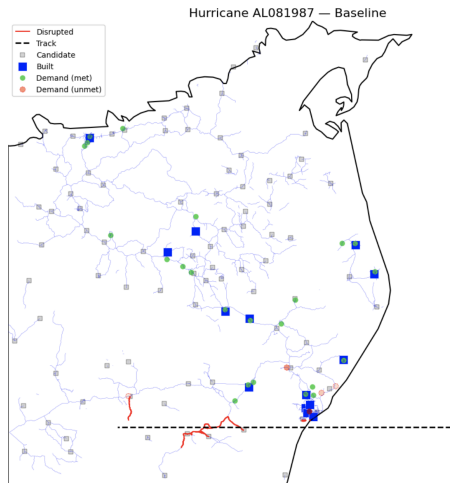


# Key Results (Time-Series CV): 26% reduction in cost

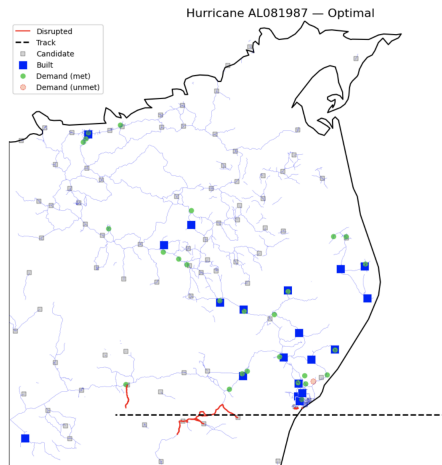


**Insight:** Higher first-stage and shipping costs lead to **much lower unmet demand penalties.**

# Spatial Results – Risk-Aware vs. Naive Design



**Baseline (no disruption):** few concentrated warehouses, severe unmet demand near landfall



**Stochastic model:** spread inland distribution + redundancy  $\Rightarrow$  robust coverage