Potential PhD Research Topic

Designing Resilient Humanitarian Logistics Networks for Remote Communities in Western Australia: A Coopetitive Multi-Objective Optimisation Approach

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Abstract

This research develops a multi-objective optimisation framework to enhance resilience and efficiency in humanitarian logistics networks serving remote communities in Western Australia. Integrating evolutionary algorithms, deep learning-based disruption forecasting, and coopetitive resilience strategies, this research develops frameworks to optimise facility location, emergency stockpile allocation, and multi-modal routing under uncertainty. By embedding predictive intelligence and cooperative mechanisms into logistics planning, this study equips decision-makers with robust, adaptive tools to maintain critical supply flows during climate-induced disruptions.

Introduction and context

Remote communities in Western Australia (WA) face persistent logistical challenges due to their geographical isolation and exposure to climate-induced disruptions such as bushfires, floods, and extreme heatwaves. These events threaten the continuity of essential supply chains, disrupt access to critical goods and medical services, and intensify the vulnerability of local populations. Improving the resilience of humanitarian logistics networks in these contexts is therefore not only a technical issue but also a vital humanitarian priority. This research proposes to develop a multi-objective optimisation framework that enhances resilience and cost-efficiency in humanitarian logistics systems supporting remote communities across WA.

The significance of this study lies in addressing the urgent need for logistics systems that can maintain service delivery during extreme and unpredictable disruptions. Traditional supply chains often collapse when roads are blocked, warehouses are damaged, or transport capacity becomes unavailable. For remote areas where communities rely on limited infrastructure and long-distance supply routes, such breakdowns can have life-threatening consequences. Enhancing the resilience of logistics networks can therefore ensure continuous access to food, water, medical supplies, and shelter during emergencies.

The proposed framework will integrate advanced mathematical modelling, evolutionary algorithms, and data-driven analytics to optimise logistics decision-making in crisis-prone environments. Specifically, it will determine the optimal locations for storage hubs, allocation of emergency stockpiles, and routing of transport across multiple modes including road, rail, and air. The optimisation model will aim to minimise delivery delays, operational costs, and the risk of supply interruption. This quantitative framework will support decision-makers in designing adaptive, responsive, and robust humanitarian logistics systems for WA.

In addition to optimising storage and distribution, the research will evaluate the strategic placement of critical infrastructure facilities that can serve both everyday operations and emergency response. Multi-functional logistics hubs will act not only as stockpile and distribution centres but also as safe shelter locations for vulnerable populations during crises such as bushfires, floods, or prolonged heatwaves. Identifying optimal locations for these facilities requires consideration of accessibility, population density, and exposure to natural hazards. Integrating these factors into logistics design ensures that networks are built to protect lives and maintain essential flows of goods under extreme conditions.

A distinctive feature of this study is the inclusion of coopetitive resilience—a framework where competing logistics providers collaborate during crises by sharing resources, infrastructure, and transportation capacity. In the vast and sparsely populated regions of WA, such collaboration can significantly improve efficiency and speed of humanitarian response. For example, shared emergency hubs and coordinated vehicle routing can reduce redundancy, lower costs, and strengthen adaptability. The study will explore how such cooperative mechanisms can be formalized into decision-support tools that promote effective coordination while preserving competition during normal operations.

To enhance preparedness, the research will employ deep learning models trained on historical data from bushfires, floods, and past supply chain interruptions in WA. These models will identify patterns in disruptions and infrastructure vulnerabilities, enabling proactive planning. The predictive insights will feed into the optimisation model to support scenario-based decision-making that explicitly accounts for uncertainty. The integration of artificial intelligence and operations research provides a strong methodological foundation for developing resilient, adaptive, and life-saving humanitarian logistics systems.

Potential Research Questions

1. What are the main infrastructure and operational challenges in ensuring resilient humanitarian logistics for remote Western Australian communities?
2. How can a multi-objective optimisation framework enhance resilience and efficiency in logistics networks?
3. What are the impacts of climate-induced disruptions on humanitarian supply chains, and how can predictive models improve preparedness?
4. How can deep learning-based forecasting support proactive decision-making in emergency logistics?
5. How can coopetitive resilience—collaboration among competing logistics providers—enhance adaptability and cost efficiency during crises?
6. What role do advanced optimisation and evolutionary algorithms play in strengthening the robustness of logistics systems under uncertainty?

Selected readings:

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