Optimization models in emergency logistics: A literature review

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Overview of the paper

- Purpose:
  - **To review** optimization models utilized in "Emergency logistics"
  - **To identify** research gaps and suggest specific future research directions

- Methodology: Content analysis
  - It seeks to establish the definition and scope of the data to be analyzed as well as targets, boundaries and context of the analysis.

Introduction

- Disaster – result of a vast ecological breakdown in the relations between man and his environment.
  - Natural (earthquakes, floods, hurricanes)
  - Man-made (terrorist attacks, chemical leakages)

- Emergency logistics
  - Process of planning, managing, and controlling the flow of ‘resources’ to provide relief to affected people

Problem with dealing Emergency logistics in real world

- Systematic planning of emergency logistics is oftentimes **neglected**

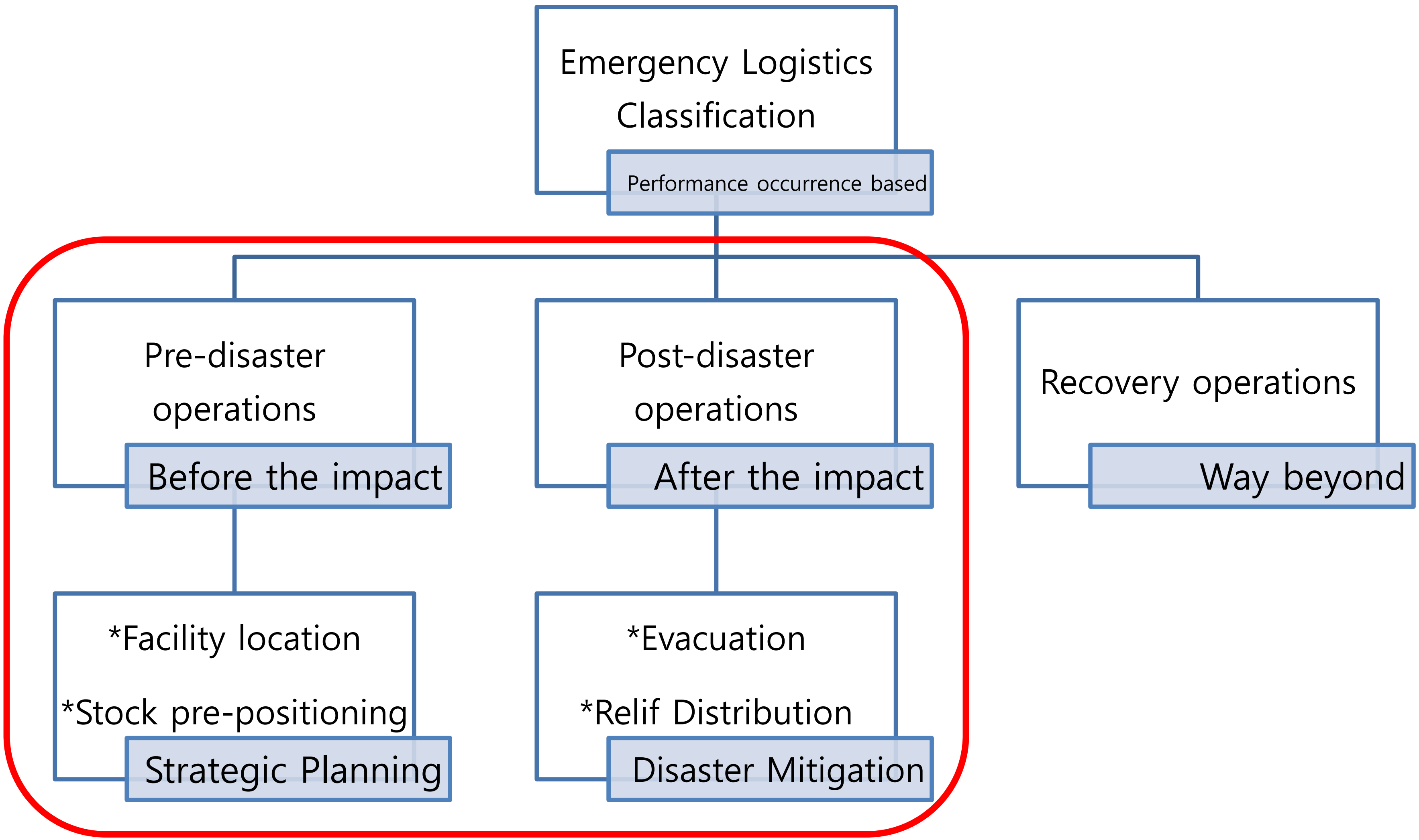
Year	Area affected	Type of disaster
2004	Indian Ocean	Tsunami
2008	Haiti	Strom
2010	Haiti	Earthquakes

- Those disasters' logistics planning conducted manually w/o experts
  - Which cost similar damages on upcoming disasters

Key Challenges to Emergency Logistics

- Additional uncertainties
- Complex communication and coordination
- Harder-to-achieve efficient and timely delivery
- Limited resources

Scope of Analysis



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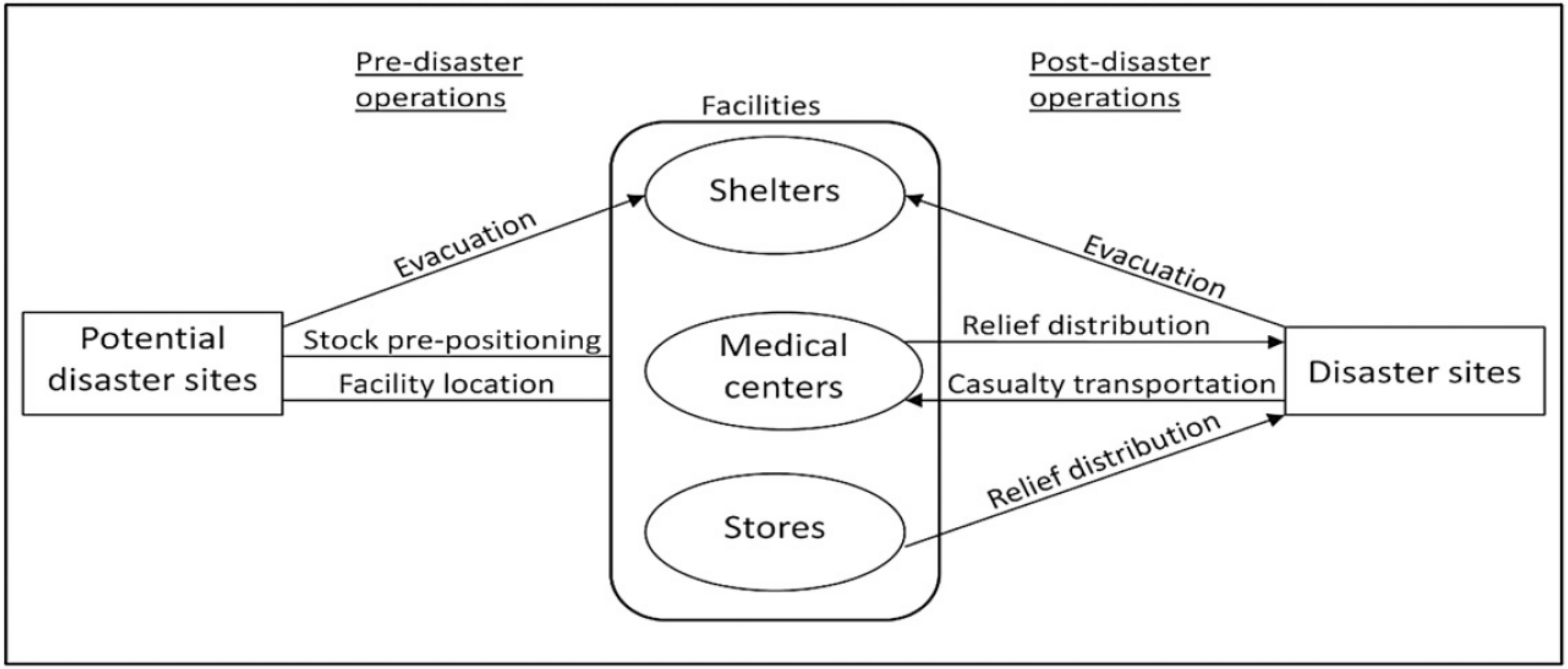
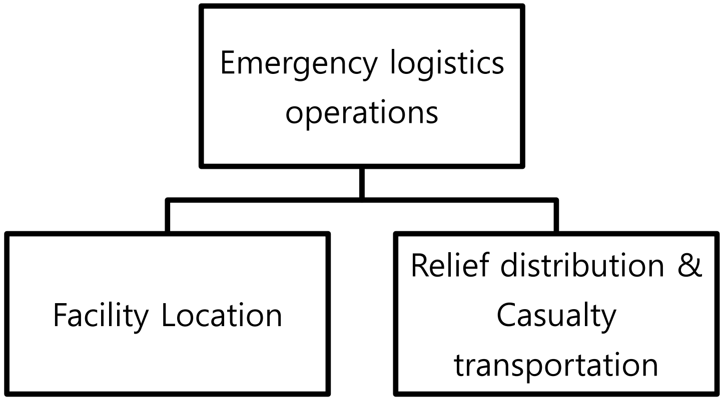
Framework for disaster operations and associated facilities and flows



- Non directional arrows do not indicate flows but rather express relationship between connected ends.

Literature breakdown and analysis



- Facility location
  - Most facility location optimization models combine the process of location with stock pre-positioning, evacuation, or relief distribution
  - It considered for location are either shelter or ware-houses
- Location-evacuation
  - All location-evacuation models built for large-scale emergency situations **seek to pick** shelters from already available locations and prescribe traffic flow plans to **minimize** total evacuation time

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Facility location models

- Location with relief distribution and stock pre-positioning

Objectives, constraints, and other decisions for location models with relief distribution and stock pre-positioning.

Author	Objectives		Constraints			Other decisions
	Cost	Time	Capacity	Requirements and bounds	Other	
Chang et al. [13]	Transportation, facility opening, equipment rental, penalties, shipping distance of rescue equipment	–	Facility	–	Prioritized facility allocation	Storage, shortage/surplus, rescue center grouping
Duran et al. [19]	–	Response	–	Number of facilities, total inventory	–	–
Iakovou et al. [34]	Facility opening, operations, transportation	–	Facility	Critical time to meet demand	–	–
McCall [45]	Transportation, shortages	–	Facility	Number of kits to pre-position	Investment budget	Unmet demand
Mete and Zabinsky [46]	Warehouse operations	Transportation	Vehicle	Inventory shortage upper bound threshold	–	Unmet demand
Psaraftis et al. [51]	Facility opening, stock acquisition, transportation, operations, unmet demand, delay	–	–	–	–	Unmet demand
Rawls and Turnquist [53]	Facility opening, transportation, unmet demand, holding	–	Facility, link	–	–	–
Wilhelm and Srinivasa [67]	Facility opening and expansion, stock acquisition, operations	–	Facility	Time-phased cleanup requirement	–	Capacity addition

- It is mainly for cost minimization
- It shows the lack of multi-objective models
  - Few models that have considered both cost and timeliness

Relief distribution and casualty transportation model

Structure of relief distribution and casualty transportation models based on planning horizon, data type, and number of levels and objectives.

		Single-period		Multi-period	
		Deterministic	Stochastic	Deterministic	Stochastic
Single-objective	Single-level	Brown and Vassiliou [11], Charnes et al. [14], Gkonis et al. [27], Knott [38], Ray [54], Sheu et al. [59]	Dessouky et al. [18]	Charnes et al. [15], Haghani and Oh [29], Özdamar et al. [49], Psaraftis and Ziogas [52], Sheu [57], Srinivasa and Wilhelm [61], Wilhelm and Srinivasa [68], Yi and Kumar [72],Yi and Özdamar [73]	Fiedrich et al. [24]
	Bi-level	–	Barbarosoğlu and Arda [5]	–	–
Multi-objective	Single-level	Viswanath and Peeta [64]	–	Sheu [57], Tzeng et al. [63], Yan and Shih [70], Yuan and Wang [74]	–
	Bi-level	Barbarosoğlu et al. [6]	–	–	–

- It is mostly multi-period it is used for post-disaster planning.
- The majority of research contemplates single-objective models
- Multi-period models are rarely stochastic

- To make it easier to solve the problem

Commodity flow model

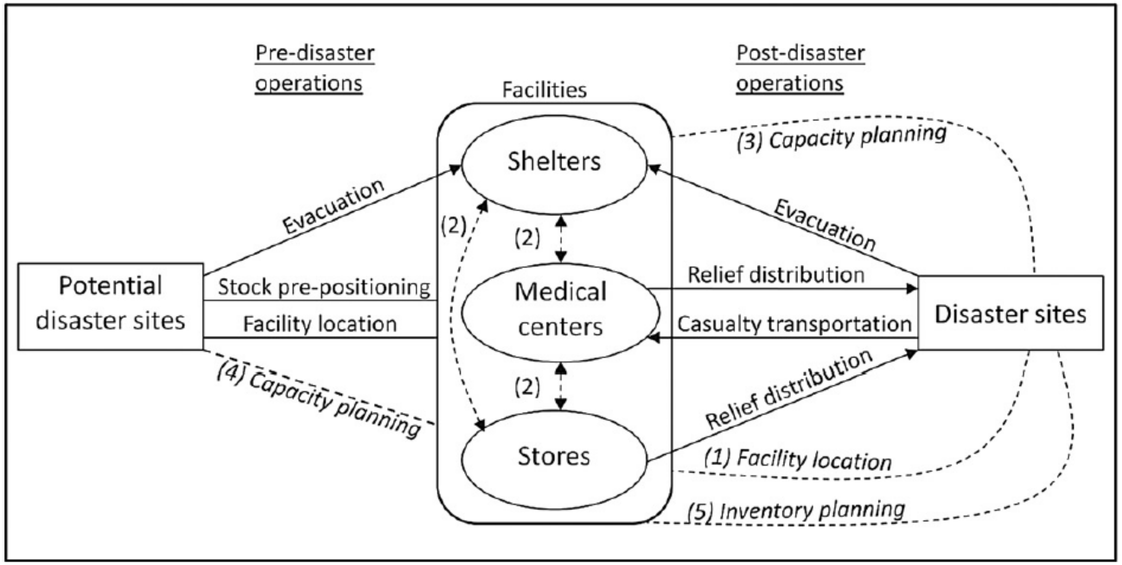
- Some researches claims that relief distribution in terms of commodity flow.
- Models that determine commodity flow deicide on the quantities to travel along specific links

Author	Objectives		Constraints				Other decisions
	Cost	Other	Capacity	Requirements and bounds	Variable calculation	Other	
Barbarosoğlu and Arda [5]	Transportation	–	Vehicle	–	Excess/shortage demand	Mode-shifting	Mode-shifting, commodity excess and shortage
Barbarosoğlu et al. [6]	Assignments of helicopters to air base and pilots to helicopters	Makespan	Vehicle, link	Upper bound for number of tours, pilot-helicopter compatibility	–	Fuel consumption	Re-fueling schedule
Dessouky et al. [18]	–	Total unsatisfied demand	–	–	–	Designated probability for service start time	Service start time of vehicles, vehicle routing
Gkonis et al. [27]	Transportation, operations, acquisition, damage	–	–	–	–	Operability of equipment with respect to oil, weather, and sea type, time limitations for dispatch	–
Haghani and Oh [29	Carry-over, transfer, transportation	–	Vehicle, link	Earliest delivery time	Exogenous supply and demand	Mode-shifting	Mode transfer, vehicle routing, carry-overs across periods
Knott [38]	Transportation	Amount of food delivered	–	Efficiency	–	–	Efficiency of truck fleet use
Özdamar et al. [49]	–	Sum of unsatisfied demand	Vehicle	–	Unmet demand	Dynamic addition of vehicles	Unmet demand, vehicle routing
Ray [54]	Transportation, storage	–	Facility	–	–	–	Storage of food

Conclusions

- This paper review optimization models used in the field of emergency logistics.
- Emergency logistics research in general remains fragmented.
- Computational efficiency is found to be the main reason for fragmented state of research in this area
  - Advance optimization algorithms make large models easier to solve
- Cross-operation models are limited.
- In an emergency situation, responsiveness appears to be the main concern
  - Most of the literature aims for better responsiveness through the objectives such as minimizing **response times**, **distance cost**

Future research directions



(1) In a dynamic and uncertain disaster environment, it is possible to consider facility location in post-situation.
(2) The possibility of incorporating stock transfer from one facility to another in a post disaster environment.
(3) When disaster strikes, facilities often become overloaded with demand, which requires service and storage capacity planning.
(4) The inventory planning can incorporate new demand patterns, ability to expand facilities.

THANK YOU