STRATEGIES FOR LOGISTICS IN CASE OF A NATURAL DISASTER

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ABSTRACT

The unpredictability of the timing of a disaster as well as the scope of its human and material destruction raises several serious questions for emergency planners and first responders. Decisions regarding the types of provisions that should be prepositioned, as well as their location, should be made well before a disaster strikes in order to provide quick response. We discuss a general framework for classifying disasters and then investigate several logistics policy options for effectively responding to them. The conceptual models developed in this work will serve as the theoretical base for future empirical work investigating appropriate policy options for different classifications of disasters.

INTRODUCTION

In 2009 there were "335 natural disasters reported worldwide that killed 10,655 persons, affected more than 119 million others, and caused over $41.3 billion in economic damages" [19]. The United Nations estimates that every dollar spent to prepare for a disaster saves seven dollars in disaster response [17]. The United States Agency for International Development (USAID) reports that of all funds used to support disaster operations, 90% are spent for response whereas 10% are spent on preparedness activities and investments and risk reduction [9]. The duration and severity of the human toll is largely dependent upon the speed and scope of the response. While there are no internationally agreed upon metrics by which to judge or measure the effectiveness of a response to a disaster, it has recently been agreed upon by scholars working in the humanitarian and disaster response research area that improvement is desirable [18] [2].

Preparedness, translates to the pre-establishment of adequate capacity and resources that enable efficient relief operations. Prepositioning of inventory such as that practiced by each of the U.S. Armed Services has proven an effective means of increasing the speed of response to a conflict [5] [1] [11].

The success of the military in using prepositioned stocks has developed interest in the prospect of using such a strategy to support operations other than war [4] [16]. While national needs for defense are well served by strategic defense inventories, disaster relief inventories, on the other hand, may serve broader goals [20], and be an effective means of supporting current U.S. strategic objectives of increasing multinational cooperation and strengthening allies, partners, and friends by mitigating human suffering during disasters. Because there is considerable similarity between the characteristics of defense inventory and disaster relief inventory the investment and management of such resources may be relatively small.

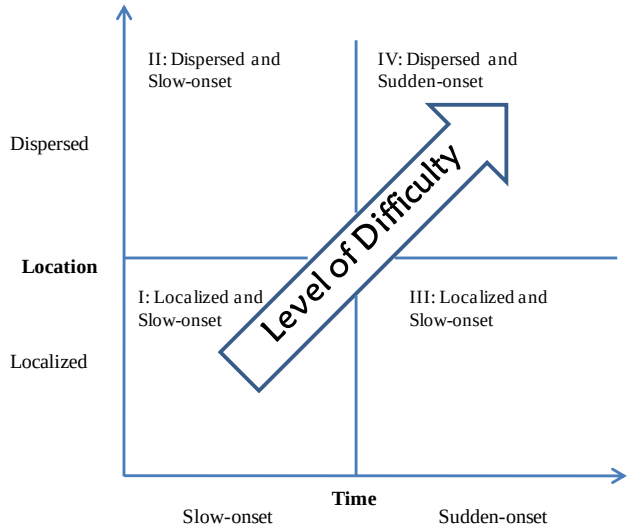
MODEL

Decisions regarding the types of provisions that should be prepositioned, as well as their location, should be made well before a disaster strikes in order to provide quick response. We investigate four policy options: 1) prepositioning supplemental resources in or near the incident location, 2) deploying federal assets in advance of a state or local government request, 3) phased deployment of assets,

analogous to the "just in time" inventory control philosophy practiced by many manufacturers, and 4) "surge" transportation of manpower and equipment from locations outside the disaster area.

Disasters are often classified based on the speed of onset and the source or cause of the disaster [18] [8]. However, in our research we focus on four disaster scenarios that are combinations of the location of the disaster (dispersed or localized) and its speed of onset (slow or sudden) as discussed by [2]. Figure 1 describes the disaster classification.

Figure 1: Classification of Disasters (Source: [2])



The classification suggests that the level of difficulty in the logistics execution is less onerous in the case of localized, slow-onset disasters because there may be adequate lead time to prepare for the response. The second quadrant describes a situation where the onset is slow but the affected areas are dispersed. When the disaster area consists of a large or scattered geographical area it may take substantial planning, resource allocation and coordination among local communities, humanitarian organizations, as well as host and foreign governments. Disaster response with just-in-time strategies may play an important role in such circumstances. However, multiple locations may pose a whole set of different issues.

The sudden-onset disaster, even if localized, creates problems in all three stages of the lifecycle of the disaster (see quadrant three in Figure 1) due to uncertainties in the demand for various types and quantities of supplies and services. While the determination of an appropriate policy for such circumstances where the disaster is sudden but localized is not clear here, the level of operational difficulty is somewhat lower as opposed to the case of a dispersed and sudden-onset disaster (represented in quadrant four of Figure 1).

The disasters with slow-onset provide time for humanitarian logisticians to plan and prepare for relief operations. A disaster that strikes suddenly can pose difficult problems for response since no organization – military or humanitarian – can fully prepare for every need that will emerge during such an event. However, prepositioning strategies such as asset placement, resource allocation, management of disaster relief inventory, and location of such warehouses may help. It is clear that whether the disaster is localized or dispersed over a large geographical area will dictate the level of difficulty involved in disaster response.

DISCUSSION

The unpredictability of the timing of a disaster as well as the scope of its human and material destruction raises several serious questions for emergency planners and first responders. For example, how can a state of supply preparedness be established and maintained? How should adequate prepositioned disaster relief inventory be established and sustained over time to include the rotation of perishable stocks? How can information regarding the location, quantity, and condition of prepositioned inventory be shared and what effect would this information sharing have on the total investment of prepositioned stocks? Is prepositioning the best strategy for all types of disasters? How reliable are the potential supply lines if it is determined that supplies should be virtually stockpiled (that is, a detailed list or database of supplies by type and quantity is created and maintained as well as reliable sources that can provide the supplies in quickly)? Should supplies be sourced locally or from outside the disaster zone? Answers to these questions depends on the expected onset speed of the disaster, volume and weight of supplies to be moved, the expected magnitude of humanitarian relief required, and the expected likelihood of a disaster in the area.

Published applicable research in the area of facility location and prepositioning may be summarized in terms of the major decision to be made and the objective and method employed in the analytic model (see Table 1). However, there remains a gap in the literature with respect to prepositioning alternatives, as well as an analysis of the appropriateness of each alternative when applied to different types of disasters.

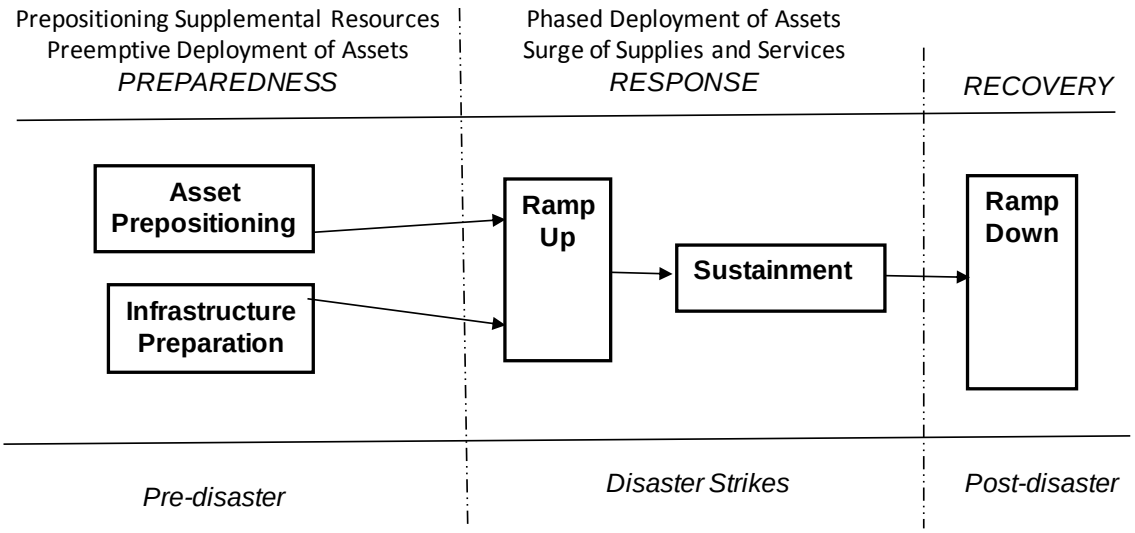
Table 1: Summary of Literature on Facility Location and Prepositioning of Assets (Source: [2])

Article	Major Decision	Objective & Method
[3] Balcik & Beamon (2008)	Number and locations of distribution centers in a relief network	Maximize total expected demand coverage using a maximal covering location model integrating facility location and inventory decision
[6] Dekle et al. (2005)	Identify potential disaster recovery centers	Minimize total number of disaster relief centers for each county residence within a given distance using a two-stage covering location problem
[7] Duran (2008)	Given initial investment find the network configuration	Minimize average response time using a prepositioning model
[10] Hale & Moberg (2005)	Establish an efficient network of secure storage facilities	Minimize number of sites supporting multiple supply chain facilities using a location set covering problem
[12] Lee et al. (2009)	Number of dispensing sites	Minimize the number of points of dispensing (POD) using a facility location model
[13] McCall (2006)	Identify preposition locations for pack-up kits	Minimize 'victim-nautical-miles' to transport kits to each disaster location using a mixed integer programming model
[14] Ozdamar et al. (2004)	Logistic plan indicating optimal mixed pick-up and delivery schedules along with optimal quantities and types of loads picked up and delivered on the routes	Minimize unsatisfied demand using a hybrid of multi-commodity network flow and vehicle routing problem
[15] Rawls & Turnquist (2006)	Location of emergency supplies and allocating quantities of those supplies	Minimize expected costs over all scenarios using a two-stage stochastic optimization model
[16] Salmeron & Apte (2009)	First stage decisions for expansion of resources and second stage for logistics	Minimized expected number of casualties and then expected number of people left behind using a two-stage stochastic optimization model

Prepositioning supplemental resources in or near the incident location most resembles the military practice of storing defense inventory ashore to be used in the event of a conflict; the Army prepositioned stocks in Southwest Asia as well as those in Korea are good examples. Another prepositioning alternative for humanitarian assistance and disaster response (HA/DR) would be to deploy federal assets in advance of a state or local government request. For example, as federal government officials see a hurricane approaching the Gulf of Mexico they could mobilize food, water, and temporary shelters and stage them close to, but not in, the expected disaster zone so that when needed the lead time is reduced. Phased deployment of assets refers to pushing inventory into a disaster area as it is needed and in the quantity in which it is needed. This disaster response is analogous to "just in time" inventory control practiced by commercial manufacturers. Phased deployment has the advantage of not committing excess inventory to a specific region before knowing precise types and quantities of supplies needed. It also prevents the disaster zone from being inundated or saturated with inbound materiel that might otherwise reduce the overall effectiveness of the disaster response due to inadequate infrastructure or limitations in personnel, material handling equipment, storage space or some combination of all three.

A surge in transportation of manpower and equipment from locations outside the disaster area is a final alternative that, rather than relying on prepositioned physical inventory, plans for excess capacity to deliver personnel and materiel in case of an emergency; in this instance, the "prepositioning" is with respect to capacity rather than inventory. The organizations involved (relevant agencies within the Department of Defense, civil and military agencies, and participating Non-Government Organizations) face issues of information availability, as well as interoperability in communications and equipment, which affect the ability to collaborate and preposition supplies. A preliminary look at the above mentioned four strategies related to the lifecycle of a disaster suggest the assignment of strategies as shown in Figure 2.

Figure 2: Policies Related to Lifecycle of a Disaster (Source: [2])



CONCLUSION

The localized, slow-onset and natural disasters are at one end of the spectrum with respect to the level of difficulty for humanitarian logistics whereas dispersed, sudden-onset disasters are at the other. The two-

dimensional classification of disasters in Figure 1 can be further enhanced by incorporating the types of supplies or services (perishable or nonperishable, critical or supportive, continuous or periodic distribution). The conceptual models developed in this work will serve as the theoretical base for future empirical work investigating appropriate policy options for different classifications of disasters.

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