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A decision-support tool for post-disaster debris operations

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Abstract

Debris generated by disasters can hinder relief efforts and result in devastating economic, environmental and health problems. In this paper, we present a decision-support tool to assist disaster and waste management officials with the collection, transportation, reduction, recycling, and disposal of debris. The tool enables optimizing and balancing the financial and environmental costs, duration of the removal operations, landfill usage, and the amount of recycled materials generated. It can support post-disaster operational decisions as well as the challenging task of developing strategic plans for disaster preparedness.

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Keywords: debris management; disaster management; humanitarian logistics; decision-support tools

1. Introduction

An important but often overlooked aspect among the post-disaster logistics activities is managing the resulting debris, which is defined as any kind of waste generated by the disaster. Types of debris include building materials such as concrete, bricks, and wood, vegetation such as fallen trees, limbs, and plantation; household waste such as furniture and white goods; hazardous waste such as industrial chemicals; cars, rubbles of road infrastructure, sediments, and so on. Timely removal of debris has important consequences in two different ways: In the short run, it enables the maintenance of disaster response activities such as relief transportation, search-and-rescue, and

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evacuation. In the long term, it prevents the adverse effects on human health and the environment due to factors such as decaying chemicals and pollution of water resources.

Debris management is a long, costly, and complicated process; therefore efficient and effective debris management operations could be significantly aided by quantitative models and decision-support tools that allow easy-to-use access to these models. Motivated by the lack of such models and tools in the literature, this paper presents a mathematical model for debris management operations in the disaster recovery stage and a decision-support tool that implements this model to provide a user-friendly application. The mathematical model balances multiple objectives such as financial costs, environmental effects, duration of the operations, and recycled debris amount. The tool can be used both in the pre-disaster stage to prepare strategic debris management plans and make what-if analyses, as well as in the post-disaster stage to determine decisions at an operational level.

Following large-scale disasters, managing the resulting debris takes a large toll on the infrastructure, economy, and human resources of the affected region. For example, the total cost of debris management activities following Hurricane Katrina in 2005, a disaster that resulted in more than 100 million cubic yards of debris, is estimated to have exceeded USD 4 billion, accounting for more than a quarter of the total cost associated with disaster response and recovery [21]. The management of post-disaster debris following the March 2011 cascading disasters in Japan was exacerbated by the fact that a substantial amount of debris was moved from its original place due to the tsunami, which also mixed different types of debris together, further complicating the removal of more than 25 million tons of debris [21]. In the Fukushima area, radioactive debris contents posed difficulties for local authorities, who were still undecided on how to carry out the removal three months after the disaster because there were no official guidelines on how to handle it [21]. The lack of space to dispose of the debris also results in challenging issues, as exemplified by the cascading disasters in Japan and the 2010 Haiti earthquake.

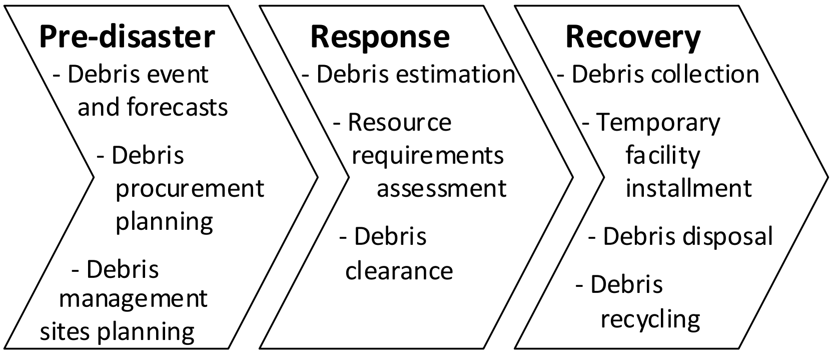

Figure 1. Flow of debris management operations throughout the disaster timeline

Adapted from FEMA [10], Figure 1 shows the debris management events throughout the timeline of a disaster. Before the disaster hits, each local community is required to determine a number of potential disaster scenarios, which in turn determine the forecasts for potential debris amounts and compositions. Based on these forecasts, workforce and equipment requirements are planned and potential debris management facilities such as debris processing sites, recycling plants, and disposal areas are determined. In the immediate aftermath of a disaster, based on the initial assessment of the disaster area, debris amounts and compositions are estimated and the workforce and equipment requirements are assessed. During this stage, debris is cleared off the roads to facilitate response activities such as search-and-rescue and relief transportation.

The disaster recovery stage involves debris collection, where the debris is transported from road and curb sides to temporary processing sites, where it may go through certain processes such as sorting, separation, grinding, incineration, wood chipping, and concrete crushing. Once these processes are complete, all or parts of the processed debris may be disposed of in landfills, whereas parts of it may be processed further to be recycled and either reused or sold.