Establishing the Need for Decision Support in Disaster Debris Disposal

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ABSTRACT

One of the most important and costly aspects of recovery operations is debris collection and disposal. The unique nature of disaster debris and the extreme amounts generated as a result of the disaster event create challenges for decision makers that are not typically encountered during every day solid-waste disposal operations. This work-in-progress research is aimed at identifying the unique aspects of disaster debris disposal and the need for decision support, which addresses these unique aspects, to assist emergency management coordinators with allocating resources during on-going debris cleanup operations. We will present a decision support system framework, discuss aspects of the knowledge base, model base, and user interface, and show how an emergency management coordinator might use the system during ongoing daily operations using real-world data from a 2003 Atlantic hurricane.

Keywords

Debris disposal, debris decision support, disaster preparedness, disaster recovery.

INTRODUCTION

Depending on the category and nature of the disaster, recovery activities can be quite complex, require effective coordination between decision makers, and involve substantial resources and cost. More importantly, the failure of emergency and disaster management decision makers to successfully coordinate recovery activities can significantly increase the time and cost of restoring damaged communities and result in severe social, political, and economic turmoil (Roper 2008). In the case of Hurricane Katrina, for example, nearly five years have passed since the storm hit the Gulf coast in August 2005 and cleanup and recovery activities, which are estimated to cost over $150 billion, have still not yet been completed. The response and recovery activities in the case of Hurricane Katrina have unfortunately illuminated the consequences of poor emergency management (FEMA 2006). Officials drew criticism from politicians and citizens for poor planning and decision-making, slow response, and inequitable allocation of resources during preparation, response, and recovery activities (Luther 2008). The degree of devastation caused by the storm, coupled with mismanagement and poor leadership, led to political and social unrest that continues today and delivered a nearly fatal blow to recovery efforts aimed at restoring the economic infrastructure of the area. Similar problems can be found in the planning, response, and recovery efforts of other disasters, including the recent earthquake in Haiti, which occurred in January 2010 and left nearly 200,000 dead and more than twenty times as many injured (Associated Press 2010).

Within the area of disaster recovery, debris disposal represents a major task requiring significant operational planning and control (FEMA 2007). The total cost of debris cleanup operations, which typically accounts for over 27% of post-disaster recovery costs, is significant and can severely impact local, state, and federal financial resources (FEMA 2006, Roper 2008). This work-in-progress research is therefore aimed at identifying the unique aspects of disaster debris disposal and illustrating how the use of quantitative modeling and the

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development of a decision support system can help decision makers allocate resources and manage cleanup operations.

DEBRIS CLEANUP OPERATIONS

Although the nature of debris or waste can vary depending on the type of disaster, disaster debris is often a mixture of all or most of the following: general household trash and personal belongings, construction and building materials, trees, vegetative and organic waste, hazardous waste, appliances, and electronic devices. Each of these categories of waste has its individual challenges for disposal even under normal conditions, and additional disaster-caused combinations of these categories often create new mixed categories with increased complexities for separating, cleaning, and disposing of the waste (Roper 2008).

Disposing of disaster debris can also be quite challenging because the amount of debris is usually extremely significant and is generated very quickly, in a matter of hours or minutes, depending on the type of disaster—far exceeding typical amounts of solid-waste generated on an annual basis. Also, in the case of large-scale disasters, debris is often spatially scattered throughout a large area encompassing several regions, counties, or states. Hurricane Katrina, which generated the greatest amount of hurricane debris ever recorded in history, deposited over 118 million cubic yards of debris over an area of 90,000 square miles, which included several states (Hansen et al. 2005, Jadacki 2007). In Louisiana alone, the storm generated over 53 million cubic yards of curbside household debris as compared to 95,000 cubic yards generated annually as a result of normal conditions. These numbers are staggering considering that the amount of curbside household debris mentioned above does not include waste from demolition and construction or any other categories such as appliances, hazardous waste, or trees, shrubs, and other organic material, which can also be significant. The Army Corps of Engineers, for example, "removed 36 million pounds of rotten meat and other food [items] from several large commercial cold storage facilities from the New Orleans area" alone (Luther 2008).

Although the locations and amounts of debris can be easily summarized looking back after recovery activities have been completed, their overwhelming and immediate nature following the disaster make them very difficult to accurately determine or forecast in real-time as recovery operations begin and while they are ongoing (FEMA 2007). Emergency management coordinators (EMCs) rely on debris inspection teams to initially survey the disaster area, which practically includes a "sweep" of important intersections and transportation routes. However, because the inspection teams are most always unable to cover or access the entire disaster-affected area and to make consistent and accurate debris estimates, this incomplete—or worse—inaccurate information can lead EMCs towards sub-optimal decisions and potentially make a bad situation even worse (Swan 2000a). Inaccurate estimates can result in inefficient allocation of resources, increased costs, prolonged recovery period, and increased social, political, and economic unrest (Roper 2008, Luther 2008).

An additional factor preventing inspection teams from accessing damaged areas is that, typically, a major portion of total debris often occurs on private property and is placed at the curbside by property owners for pick-up by public workers or contractors (FEMA 2007). This process forces disaster management coordinators to rely on estimates from property owners who decide to call the disaster operations center to report debris for pick-up and on estimates based on daily disposal amounts, both of which provide uncertain, incomplete information regarding the entire situation. As a result of this uncertainty, EMCs are looking for effective ways to accurately estimate debris locations and quantities, prioritize damaged areas, and assign debris removal teams for cleanup (Luther 2008, McCreanor 1999, Roper 2008, Swan 2000b, Trimbath 2005).

The total cost of debris cleanup operations is significant. In the case of Katrina, for example, administrative debris cleanup costs alone were estimated to approach $330 million, accounting for over 8% of total debris disposal costs that have totaled more than $4.4 billion (Jadacki 2007). While a portion of debris cleanup is subsidized by federal agencies, primarily the Federal Emergency Management Agency (FEMA) and the Federal Highway Administration (FHWA) when a federal emergency has been declared, the majority of debris cleanup costs remain the responsibility of local and state governments. Spending too much on debris cleanup can strain financial resources, jeopardizing the success of rebuilding and restoration efforts.

The combination of these factors, along with an extreme sense of urgency to dispose of the debris as quickly as possible, creates challenges quite different than challenges of everyday solid-waste disposal. Emergency management personnel seeking to efficiently and equitably allocate resources—funds, personnel, equipment, landfill space, etc.—in support of response and recovery operations. On one hand, debris removal is critical for saving lives. As quickly as possible, rescue teams need clear pathways in order to reach and evacuate people from the danger zone and to deliver life-sustaining aid to people in affected areas. On the other hand, debris removal is necessary for returning the physical, economic, and social infrastructure to pre-disaster conditions. As efficiently and equitably as possible, rebuilding teams need to cleanup damaged areas, restore life-sustaining infrastructure services such as water, sewer, electric, and telephone, and repair and rebuild structures damaged or destroyed from the disaster.

As a result, debris removal activities are commonly organized into two phases. During the first phase, the objective is to clear debris from evacuation and other important pathways. Preventing further damage to property, separating and disposing of debris and other considerations are secondary considerations in this phase. Practically, phase one activities largely consist of pushing fallen trees and debris blocking streets and highways to the curb and is generally completed in a relatively short period of time—usually within 24 to 72 hours. In phase 2 of debris removal, which can take months or longer, speed of debris removal remains an important consideration, but now additional objectives such as equitably allocating recovery resources, efficiently locating temporary separation and disposal facilities, maximizing recycling, and responsibly managing the overall costs of recovery become increasingly important (City of Chesapeake 2007, FEMA 2007).

Accurately estimating the locations and amounts of debris are critical to successfully allocating resources and assigning debris disposal teams for cleanup. Debris amounts can vary depending on the type and nature of a disaster. For example, Hurricanes Isabel in 2003 and Bonnie in 1998, both category 2 hurricanes accompanied with relatively low precipitation when they made landfall, generated over 1 million and 350,000 cubic yards of organic debris (trees, shrubs, etc.) respectively and very little construction and demolition debris. In contrast, Hurricane Floyd, also a category 2 when it made landfall, but accompanied with record precipitation, generated very little vegetative debris, and more construction and demolition debris as a result of severe floods (City of Chesapeake 2007). Although hurricanes draw much attention in terms of debris, other types of disasters such as tornadoes, wildfires, earthquakes, volcanic eruptions, floods, etc. that affect large areas may include additional categories of debris and can also bring similar challenges. Looking back after all debris removal operations have been completed, the locations and amounts of debris cleaned up can be easily calculated. However, at the onset and while operations are ongoing, accurately estimating the locations and amounts of debris is one of the most difficult challenges for EMCs in search of effective methods for equitably allocating resources during debris cleanup operations (City of Chesapeake 2007, McEntyre 2007).

LITERATURE REVIEW

Debris disposal is one of the most important activities of disaster recovery, which has received the least research attention of the four stages of disaster management (Altay and Green 2006). The nature and importance of debris cleanup to the success of recovery operations has primarily been discussed qualitatively in the relatively few articles published in the academic literature. For example, Roper (2008) discussed the challenges involving debris cleanup following Hurricane Katrina and the need for increased recycling efforts. Dubey et al. (2007) discussed the disposal problems associated with large amount of arsenic treated wood in the debris. Many popular press, industry journals, and government documents have published articles discussing debris cleanup related to specific disasters (Hansen et al. 2005, Luther 2008, Stephenson 2008, Trimbath 2005), the need for debris planning and management (City of Chesapeake 2007, EPA 2008, FEMA 2007, Jadacki 2007, McCreanor 1999, Swan 2000b), and the general nature of disaster debris (Farrell 1999, Swan 2000a).

There have been relatively few quantitative studies published in the literature. Wei et al. (2008) propose a decision support system for estimating debris flow resulting from a flood. The proposed DSS is discussed in terms of its use during planning activities for estimating debris flows, evacuation planning, and mitigation activities. In a recent study, Fetter and Rakes (2010) propose using statistical process control methods to equitably allocate resources during ongoing disposal operations.

Studies proposing decision support systems and tools are also relatively few. Thorneloe, et al. (2007) discuss a decision support knowledgebase under development at the U.S. Environmental Protection Agency (EPA) that aims to provide relevant "technical information, regulations, and other information" that would help decision makers with disposal decisions. The HAZUS-MH system developed by FEMA helps decision makers estimate potential damage and costs resulting from potential disaster events. The DDST tool recently developed by the U.S. Homeland Security Agency also aims to help emergency management coordinators with disposal decisions by providing guidelines and a database of resources. We are unaware of any other published research studies, such as the one we propose here, developing a decision support tool for assisting emergency management coordinators with daily operational aspects of disaster debris disposal operations.

WORK-IN-PROGRESS RESEARCH OBJECTIVE

This work-in-progress research is aimed at developing a decision support system to assist emergency management coordinators with allocating resources during debris cleanup operations. We will present a decision support system framework, discuss aspects of the knowledge base, model base, and user interface, and show how an emergency management coordinator would use the system during ongoing daily operations. Finally, we will demonstrate the usefulness of the system using real-world data from a 2003 Atlantic hurricane.

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