A First Step in Decision Support Tools for Humanitarian Assistance during Catastrophic Disasters: Modeling Hazard Generated Needs

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ABSTRACT

The US has not yet developed adequate models for estimating hazard generated needs, the necessary first step for developing useful decision support systems needed to estimate the capability and capacity of the response forces required. Modeling and technology required to support the decisions made by humanitarian relief organizations requires scenario driven catastrophic planning. This paper documents the lack of effective decision support tools and systems for humanitarian aid and describes the current state of models and methods used for determination of hazard generated needs. The paper discusses work performed on a catastrophic earthquake preparedness project. It outlines how the results of this project will be used to advance the modeling and decision support capabilities of federal, state and local disaster planners and emergency responders.

Keywords

Catastrophic Event Planning, Humanitarian Assistance, Decision Support

INTRODUCTION

The US response to Hurricane Katrina (2005), the international response to the Pakistan/Kashmir earthquake (2005), to the Andaman Nicobar (Aceh) earthquake and tsunami (2004) all demonstrated that catastrophic events exceed our ability to (1) accurately anticipate hazard generated humanitarian needs, (2) to develop the capacity and capability to meet these needs, and (3) to deploy adequate resources to minimize human suffering. The response to such events is determined by what governments and NGO's are capable of providing, not by an accurate forecast or situational assessment of what is needed. This paper describes a FEMA funded project currently conducted by the University of Illinois Mid American Earthquake Center and the George Washington University Institute for Crisis Disaster and Risk Management which will attempt to bridge the gap between damage and loss estimation models and the estimation of humanitarian needs. The paper provides some implications for the development of decision support systems for catastrophic event preparedness and response.

HAZARD GENERATED NEEDS

As shown in figure 1, Quarantelli (1988) separates disaster needs into two categories: hazard generated needs and response generate needs, recognizing that the launching of a response force creates additional demands such as

communication, information management, and internal logistics requirements. Meeting the hazard generated needs becomes the basis for estimating the services required from response forces and therefore the size, type and capability of this force.

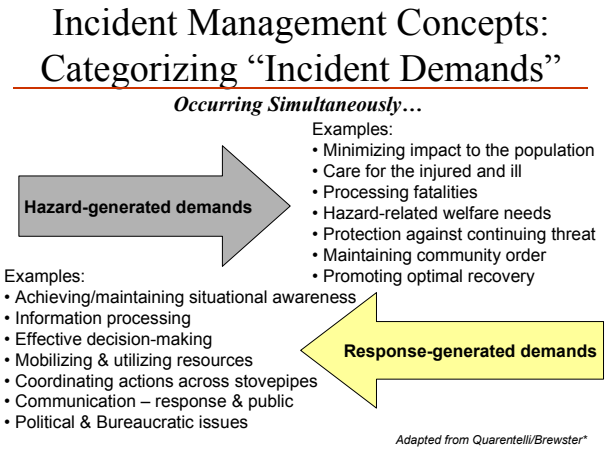

Figure 1. Hazard-generated Demands and Response-generated Demands[1]

In the absence of accurate methods to estimate these needs, planning is difficult as well as inaccurate.

MODELING AND DECISION SUPPORT

In order to make the transition from a paradigm of "doing the best we can with what we have" to a paradigm of "being prepared to do what is needed", improved methods and models for estimating impacts and consequences of extreme event are required. These models should be based on pre-event scenario estimates, combined with pre-event capabilities assessments, allowing the development of scenario driven catastrophic planning which is an important input to the response activity.

The US FEMA and the National Institute of Building Sciences have developed a loss estimation modeling system called HAZUS (FEMA, 2006). HAZUS was originally developed to estimate losses due to earthquakes. The recently released HAZUS-MH provides loss estimation capability for earthquakes, floods, and wind. It also provides an estimate of displaced persons and sheltering needs based on a multi attribute model developed by Harrald (Harrald, Fouladi, and Al-Hajj, 1992) funded by the American Red Cross. The model structure and the weights assigned to attributes are based on the expert judgment of Red Cross shelter managers and a survey of Northridge Earthquake victims (Harrald et al., 1992). The model was extended in projects funded by the National Science Foundation and conducted in partnership with the Association of Bay Area Governments (ABAG) and has been used as a primary source for earthquake mass care preparedness planning in the San Francisco Bay Area (Perkins, et al., 1996, Harrald, Renda-Tanali, Bettridge, and Perkins, 2000). In this model, the probability that a household will seek shelter is determined by the level of damage and type of residence, along with the socio-economic and demographic variables describing the residents. The shelter model in HAZUS is a simplified version of this model. The HAZUS model neglects several problematic issues, not adequately addressed in the original model. These include failing to account for pre-disaster homeless, and to account for the empirical observation that a small percentage of people from undamaged dwellings seek public shelter due to fear of aftershocks or mistrust of their

structure or to estimate the number of people forced to evacuate their homes due to secondary hazards (e.g. potential dam failure, hazardous material release, etc.).

In spite of these shortcomings, the shelter models used by ABAG and incorporated in HAZUS are reasonable predictors of the demand for public shelter and can be used to estimate required response resources (see Harrald et al., 2000). Adequate models that would enable planners and responders to estimate other hazard generated needs such as the required capacity for feeding and mass care commodities, as well as medical requirements do not exist. These are difficult needs to estimate. The calculation of food and water requirements for persons in public shelters is straight forward and based directly on the estimated shelter populations. The calculation of food and water requirements of persons still in their homes is much more difficult. If people have power, they can feed themselves as long as they have access to food and water supplies. If they cannot prepare food, then distribution of prepared food and/or Meals Ready to Eat (MRE's) is required. Similarly, the determination of medical resources needed requires not only the estimation of the number of injured persons (a HAZUS output), but also the estimated type and severity of injuries sustained. The projection of medical requirements also requires an assessment of the impact of the event on medical resources in the affected area.

Rapid Assessments

There has been a significant development of estimating techniques based on decision rules by international non government organizations. Structured information gathering is practiced by the US Office of Foreign Disaster Assistance (USAID, 2005), The International Federation of Red Cross and Red Crescent Societies (IFFRC 2005), and the Pan American Health Organization (PAHO, 2000)).

The Rapid Assessment Process (RAP) supported by USAID provides guidelines and forms for the post disaster estimation of temporary housing requirements, health requirements, and food and water requirements (see http://www.rapidassessment.net/). The Asian Disaster Preparedness Center (Asian Disaster Preparedness Center, 2000) has also developed a structured approach to information gathering and presentation.

Assessment methodologies lack models that facilitate the transition from information describing physical and social impacts to the estimates of humanitarian needs and service delivery requirements. These estimates are made by experienced relief workers based on the best available information. International efforts thus far have been focused on improving the quality of the information and providing structure for its collection and presentation. A major US project, funded by FEMA provides the opportunity to take significant steps toward providing mature decision support tools for humanitarian assistance.

IMPLICATIONS FOR HUMANITARIAN ASSISTANCE DECISION SUPPORT SYSTEMS

The need for more sophisticated decision support tools to support emergency management and humanitarian assistance has been well documented (National Research Council, 2007). There are complex and difficult modeling and data issues that need to be resolved before decision makers faced with a catastrophic event such as Hurricane Katrina or the Andaman-Nicobar earthquake and tsunami, will be able to rely on decision support tools based on information technology.

Current humanitarian assistance models are often based solely on individual's experience and expertise. Pre-event modeling and prediction are seldom available and post event field data collection during humanitarian assistance is often difficult. As a result the availability and quality of baseline data is limited. However, progress in model and decision support system development should not be constrained by present data limitations. Improved models can lead to more realistic planning assumptions and robust preparedness strategies. Model building also provides the motivation for improved data availability. While relevant input parameters for hazard and response generated demand models can be determined somewhat easily, the creation and validation of the models themselves is complicated. Although expert judgment, social sciences and related research fields can help to better understand human behavior during disasters, the results may only be valid for a specific social context and therefore hardly transferable to other geographic areas. So far the availability of quantitative data is very limited and therefore the validity of the models is hard to prove. In the short term it may be sufficient to create adequate plausible but not fully validated models.

THE NEW MADRID SEISMIC ZONE PROJECT

FEMA has funded a major project to support the planning and preparation for potential future catastrophic events. Earthquakes in the New Madrid Seismic Zone (NMSZ), located in the central United States, have been selected as hazard scenarios that will be studied as part of this effort. This project will be conducted by a team consisting of Innovative Emergency Management (IEM), the Central US Earthquake Consortium (CUSEC), the University of Illinois Mid America Earthquake Center (MAE Center). The MAE Center, using and updating HAZUS and using its own loss estimation and visualization tool MAEVIZ will produce loss and consequence estimate for the 8 state New Madrid region. The George Washington University Institute for Crisis Disaster and Risk Management (ICDRM) will conduct a requirements analysis and definition of model parameters for response and recovery planning for the estimation of medical, health, mass care, and critical commodity needs. The MAE center effort will provide unique inventory, seismic, and population data and loss models. The GW service delivery requirements models will be a unique extension of current practice. Together these elements will enable the development of a decision support systems that will support planners and response decision makers estimate hazard generated needs.

With the exception of a very rough estimate of sheltering demand, HAZUS does not produce the information required by planners and responders needed to estimate the response resources and capability required when planning and responding to a catastrophic event. The project objective is to bridge the gap between what is often seen as two disjoint activities: (1) loss estimation modeling and (2) preparedness and response decision making. This effort is one of the firsts in this area to incorporate research modeling into current practices for planning and response. Figure 2 provides an overview of the current research activities. The result is scenario driven catastrophic planning. When a hazard does occur, this planning becomes the first input into the decision making required by response activities.

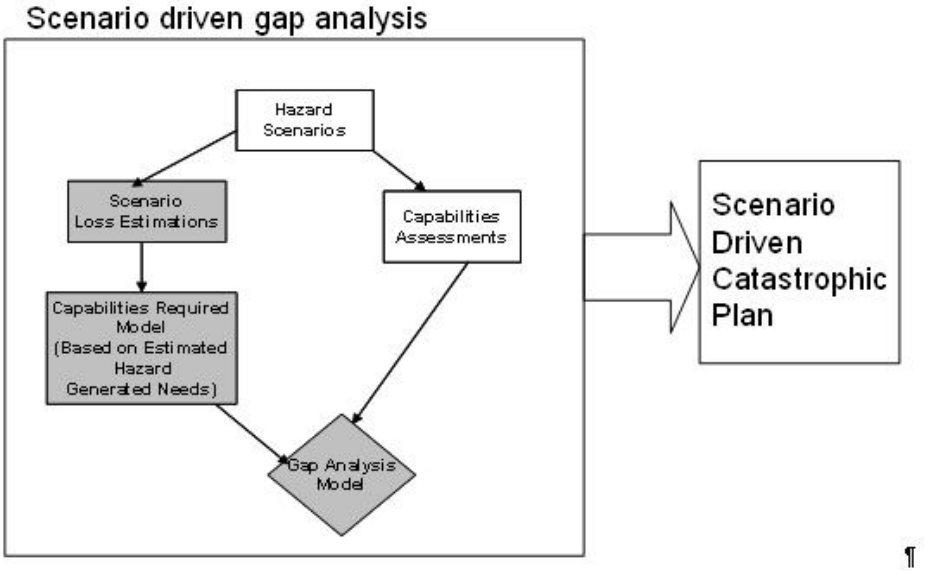

Figure 2. **Developing Scenario Driven Catastrophic Plans**

The Capabilities Required Model shown in figure 2, uses numerous loss estimation variables. Table 1 provides a subset of various loss estimation variable used to predict hazard generated welfare needs.

Hazard generated welfare needs required for preparedness and response decisions	Loss estimation variables used to predict hazard generated welfare needs
Medical supplies (pharmaceuticals)	Housing damage, population demographics, power loss, transportation network loss, damage to medical facilities
Temporary shelter/temporary housing	Housing loss., population demographics, income distribution of population. Owner/renter distribution
Mass feeding	Housing damage, power loss, transportation infrastructure, population demographics
Critical commodities (water, food, ice)	Impact on water infrastructure, transportation infrastructure, housing damage, population demographics)

Table 1. Loss estimation variables used to predict hazard generated welfare needs

This model will combine the data above with various heuristics provided by domain experts to produce estimates of hazard generated needs under a variety of different scenarios. The outputs of the Capabilities Required Model together with a Capabilities Assessment can then be used to perform a Gap Analysis. Currently this research is focusing on developing the Capabilities Required Model. The following is an outline of the steps that need to be completed.

- Precise description of relevant hazard-generated needs and definition of priorities for model building
- Definition of relevant model input variables and parameters under consideration of possible data availability
- Review of different possible modeling approaches, including usability for the humanitarian assistance domain
- Model building
- Sensitivity analysis for a study region
- Verifying the plausibility of the models through expert surveys with emergency managers
- Inclusion of model results into disaster plans of study region

The ultimate objective of this project is to allow for the processes shown in Figure 2 to be combined with the HAZUS system to develop a new tool that is capable of producing Scenario Driven Catastrophic Planning.

Many issues remain. These include, for example, license restrictions for data provided by private companies and the willingness of the local governments to share planning relevant data. Once the databases are in place it must be ensured that the databases are kept up-to-date and issues regarding data quality are addressed.

We believe that the quality of the humanitarian assistance planning and response can be substantially improved when communities use models that are not solely based on post-event data but also on pre-event data and appropriate requirement models.

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