Chapter 18
A Multiple Natural Hazards Assessment Model Based on Geomorphic Terrain Units

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ABSTRACT

A Multiple Natural Hazards Assessment (MNHA) procedural model was developed to provide stakeholders (e.g., community planners and decision makers) with a clear methodology that examines the landscape as a probabilistic-based composite measure of the natural hazards at a terrain mapping unit scale. The model consists of four phases: (1) data collection; (2) individual natural hazard assessment (INHA); (3) Geomorphic Terrain Unit (GTU) development; and (4) composite MNHA classification. The model was tested in a case study across southern Davis County, Utah. Six hazards were integrated within a GIS model, producing a nonweighted probabilistic-based multi-hazard classification across GTUs. Examination of the results by stakeholders showed great potential for the model. During the evaluation workshop, stakeholders concurred that normalizing the class values using a simple frequency-based scale makes it easier to discern the differences in composite hazardousness across the community. The model is easily expanded to include objective or subjective weighting factors.

INTRODUCTION

Need for a Probabilistic-Based Multiple Natural Hazards Assessment

Within the United States, the vulnerability to hazards is rising significantly because more dwellings and infrastructure are being built along the human-environmental interface (Federal Emergency Management Agency, 1998). This leaves little buffer between communities and hazardous natural processes. Within this context, critical information on the magnitude, frequency, and distribution of the hazardous processes is needed for developing appropriate mitigation strategies. The US Disaster Mitigation Act of 2000 (i.e., DMA 2000) formally established a hazard mitigation program that requires state, tribal,

and local governments to perform mitigation planning as part of their applications for aid to mitigate hazards. This includes the development of multi-hazard maps used in composite hazard, vulnerability, and risk assessments of communities. As recognized in DMA 2000 and recent research publications, studies done on individual natural hazards are limited because they do not consider a composite measure for the multiple hazardous processes that impact the landscape (Tate et al., 2010; Greiving et al., 2006; Bell & Glade, 2004; Cutter et al., 2000). Probabilistic-based multiple natural hazards assessments (MNHAs) can provide a more realistic perspective on the occurrence and significance of natural hazards across the landscape. MNHAs can be used as inputs for completing vulnerability and risk assessments, which ultimately provide a better understanding of the problems facing communities along the human-environmental interface.

With today's easy access to advanced geospatial technologies and digital data through various organizations' web portals, community planners can conduct detailed probabilistic hazards analyses and incorporate the results into their master plans to prioritize pre-disaster mitigation efforts in their communities. However, most do not have the time, resources (human or software) or expertise to develop multi-hazard assessments that can be analyzed as well as input into multi-hazard vulnerability and risk assessments. Such was the impetus that led to the development of this model, constructed using Geographic Information System (GIS) object-based graphic tools that are easily executed in a common GIS platform on a local computer or through web-based services.

Community planners, geospatial analysts, emergency managers, and decision makers (i.e., the stakeholders) are intended as the primary audience for this model. The community-scale information generated from such an assessment will lead to a good understanding of the geographic distributions, the critical thresholds (magnitude), and the exceedance probabilities of the predominant hazards in the community. This will lead to better understanding of the vulnerabilities and risks that require decisions on how to effectively distribute resources to mitigate the hazards, provide advance warning, and lead to improved response times in disaster situations.

Previous Work

Several research efforts that address forms of multi-hazard assessment have been published in the last 40 years. Among these, Hewitt and Burton (1971) released the classic work on multi-hazard assessment for a specific location. They examined the town of London, Ontario, Canada, and developed a joint-risk magnitude for all hazards based on analysis of historical records for hazard events over the previous 100 years. Later, Montz (1994) demonstrated the capabilities and limitations of multi-hazard assessments through a project in Rotorua, New Zealand. She adapted the analytical framework for integrating physical and human systems developed by Hewitt and Burton (1971) and analyzed the independent multiple hazards for a specified mapping unit (a city neighborhood). This laid the groundwork for composite multi-hazard assessments incorporating both primary and secondary processes.

Recent publications on both multi-hazard vulnerability assessments and risk assessments have further demonstrated the necessity of examining the impact that multiple hazards, as a composite group, have on calculating the overall vulnerability and risk in communities. Cutter et al. (2000) completed a GIS-based case study for Georgetown County, South Carolina, using the "hazards-of-place" model of vulnerability developed in earlier seminal research (Cutter, 1996). The model incorporated both social and biophysical vulnerabilities to produce place vulnerability based on multiple hazards (i.e., composite hazard assessment) at the county level. Previous hazards research focused mostly on biophysical vulner-

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