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Mapping of hazard from rainfall-triggered landslides in developing countries: Examples from Honduras and Micronesia

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ABSTRACT

Loss of life and property caused by landslides triggered by extreme rainfall events demonstrates the need for landslide-hazard assessment in developing countries where recovery from such events often exceeds the country's resources. Mapping landslide hazards in developing countries where the need for landslide-hazard mitigation is great but the resources are few is a challenging, but not intractable problem. The minimum requirements for constructing a physically based landslide-hazard map from a landslide-triggering storm, using the simple methods we discuss, are: (1) an accurate mapped landslide inventory, (2) a slope map derived from a digital elevation model (DEM) or topographic map, and (3) material strength properties of the slopes involved. Provided that the landslide distribution from a triggering event can be documented and mapped, it is often possible to glean enough topographic and geologic information from existing databases to produce a reliable map that depicts landslide hazards from an extreme event. Most areas of the world have enough topographic information to provide digital elevation models from which to construct slope maps. In the likely event that engineering properties of slope materials are not available, reasonable estimates can be made with detailed field examination by engineering geologists or geotechnical engineers. Resulting landslide hazard maps can be used as tools to guide relocation and redevelopment, or, more likely, temporary relocation efforts during severe storm events such as hurricanes/typhoons to minimize loss of life and property. We illustrate these methods in two case studies of lethal landslides in developing countries: Tegucigalpa, Honduras (during Hurricane Mitch in 1998) and the Chuuk Islands, Micronesia (during Typhoon Chata'an in 2002).

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1. Introduction

A large portion of the world's landslides are triggered by earthquakes, volcanoes, and severe rainfall in parts of the world where resources are few, and the ability to document and analyze landslides is limited. Many countries in Central and South America, islands in the Caribbean and Pacific Oceans, and developing countries in southeast Asia are repeatedly exposed to landslide-triggering events and have extremely high vulnerability to flooding and landslide hazards (Fig. 1). During the 1990s and into the following decade, island countries in the Pacific sustained more disaster-related mortality, percentage of population affected, and disaster damage costs per capita GNP than any other area in the world (Mark Keim, Center for Disease Prevention and Control (CDC), unpublished data, 2004). Islands and coastal areas are particularly vulnerable to natural disasters (such as hurricanes, tsunamis, etc.) and commonly have a limited capacity (due to spatial isolation) to respond to and recover from such events. Because of their limited resources and yet high vulnerability to landslide and other hazards, developing countries often have an even greater need for maps depicting natural hazards than do industrialized countries with access to considerable resources. Alcántara-Ayala (2002) contends that the impact of natural hazards is greater in developing countries because these countries tend to be located within geological and geomophological zones of high hazard and that economic, social, political, and cultural conditions can be poor and therefore magnify vulnerability.

Landslide-hazard analysis within a Geographic Information System (GIS) framework has been applied to slope-stability problems in developing countries with increasing frequency. . Notable examples were performed following landslide disasters induced by Hurricane Mtich in Central American countries (Alcántara-Ayala, 2002; Zaitchik et al., 2003 (landslides triggered by Hurricane Mitch in Honduras); Guinau et al., 2007, 2005(landslides triggered by Hurricane Mitch in Nicaragua)). Recent investigators (Guinau et al., 2005) have suggested that statistical (rather than physically based) approaches that correlate numerous factors with landslide occurrence are best suited

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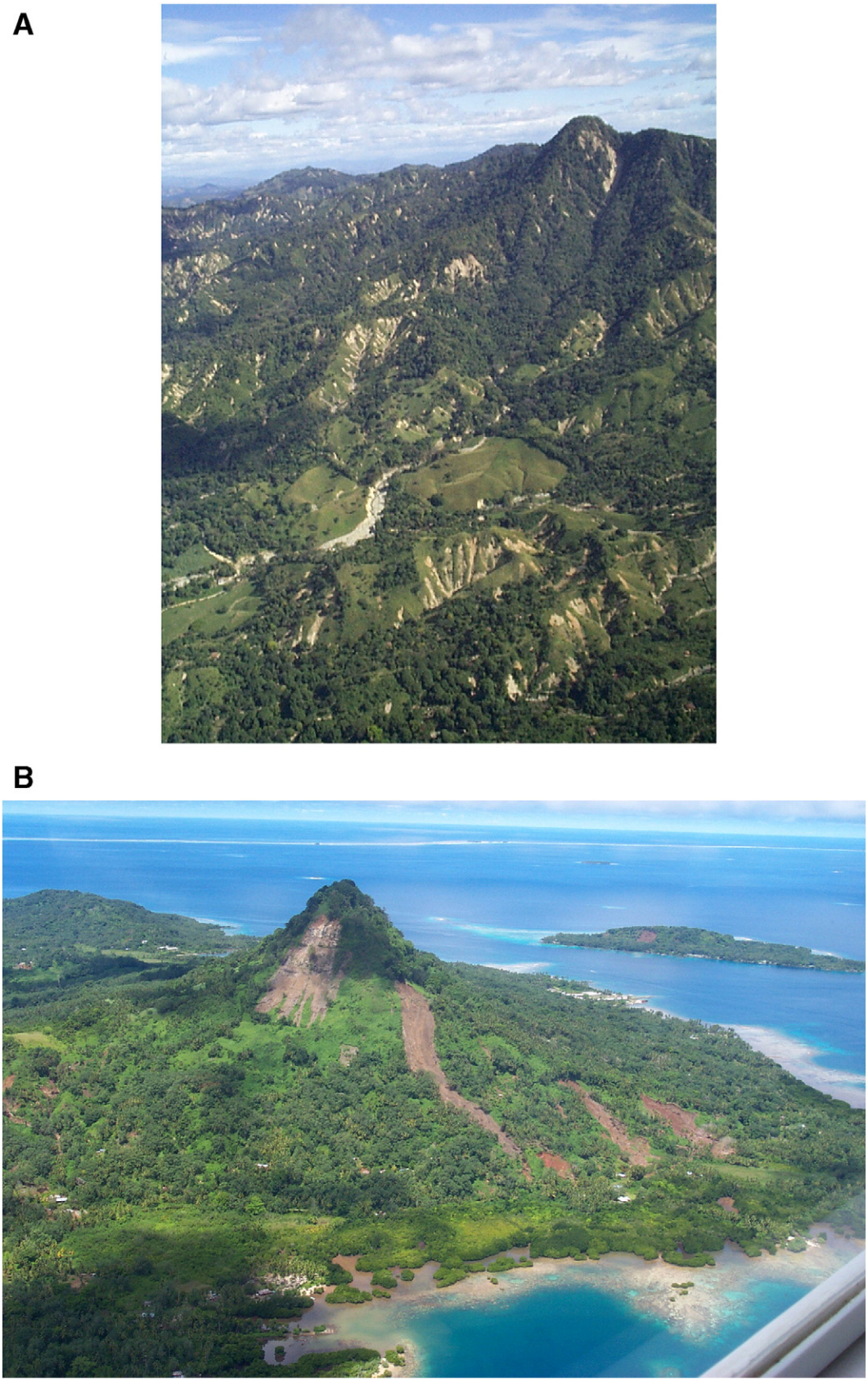

Fig. 1. A) Numerous debris flows in southern Honduras triggered by intense rainfall from Hurricane Mitch. B) Landslides (mainly debris flows) triggered by Typhoon Chata'an in the islands of Chuuk State, Federated States of Micronesia.