

# A Review of Geospatial Information Technology for Natural Disaster Management in Developing Countries

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## ABSTRACT

*Disasters are deadly and destructive events, particularly in developing countries where economic, social, political and cultural factors increase natural hazard vulnerability. The recent devastation of the Haiti earthquake on January 12<sup>th</sup>, 2010 was a prime example of the human toll a natural disaster can take in developing regions of the world. There is an imminent need to improve natural disaster management capacity in developing countries to reduce disaster impacts. Given that disasters are spatial phenomenon, the application of geospatial information technology (GIT) is essential to the natural disaster management process. However, in developing countries there are numerous barriers to the effective use of GIT, especially at the local level, including limited financial and human resources and a lack of critical spatial data required to support GIT use to improve disaster management related decision making processes. The results of a thorough literature review suggests that currently available free and open source GIT (FOS GIT) offers great potential to overcome some of these barriers. Thus, disaster management practitioners in developing countries could harness this potential in an attempt to reduce hazard vulnerability and improve disaster management capacity. The use of FOS GIT significantly reduces software costs and can help build local level GIT knowledge/technical skills that are required for successful GIT implementation.*

*Keywords: Disaster, FOSS, Geographic Information System, GIS, GIT, Hazard, Open Source Software, Remote Sensing, Software*

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## INTRODUCTION

Although the United Nations designated the 1990's as the International Decade for Natural Disaster Reduction (IDNDR), there was a global failure to reduce natural disaster impacts during

that time (IFRC, 2001). Ultimately contributing to this trend are environmental degradation, rapid urbanization and social marginalization (McEntire, 1999), particularly in developing countries. The increasing number of disasters suggests that vulnerability to natural hazards is also rising and so equates to changing the geography of risk. By way of elaboration, more

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people are living in low-lying coastal zones, seismically hazardous areas and concentrated urban environments (Amendola *et al.*, 2008; Briceño, 2004; Burton *et al.*, 1993; El-Masri & Tipple, 2002). Vulnerable populations will be at increased risk, for example, as the geography and magnitude of hydrometeorological hazards that are historically associated with some of the greatest disasters (Kondratyev *et al.*, 2002) change with global climate (Smith, 2004; IPCC, 2007). Defining the geography of risk is of a major concern in general and in particular in developing countries, “where disasters jeopardize important social development goals such as addressing poverty, ensuring adequate food, water, and sanitation, and protecting the environment,” (Levy 2005, p.375). Because natural disasters have the greatest overall impact in developing countries (Alexander, 1995; Bui *et al.*, 2000; IFRC, 2001), this is where geospatial information technologies (GIT) have the greatest potential to mitigate casualties.

The purpose of this paper is to examine the use of GIT for natural disaster management, with an emphasis on how these technologies, in particular free and open source GIS (FOS GIT) can be effectively utilized at the local level in developing countries. Although natural disasters cannot entirely be prevented, disaster losses (including human, environmental and infrastructure/personal property) can be minimized with effective disaster management—the process of mitigation, preparation, response and recovery. The field of disaster management has greatly benefited from recent advancements in computers and related information technologies. Geospatial information technologies (GIT), including geographic information systems (GIS), remote sensing (RS), global positioning systems (GPS) and Internet GIS (IGIS) are currently being employed in a variety of ways to support all phases of disaster management. Since “each phase is geographically related to where people, places, and things are spatially located” (Gunes & Kovel 2000, p. 136), the entire disaster management process can be significantly enhanced through the effective

use of GIT (Goodchild, 2006). “Even though the natural processes (e.g., floods, earthquakes, landslides, etc.) that generate disasters might be fundamentally different, the techniques to assess and mitigate risk, evaluate preparedness, and assist response have much in common and can share and benefit from advances in geographic information science (GIScience) (e.g., data acquisition and integration; issues of data ownership, access, and liability; and interoperability).” (Radke *et al.* 2000, p. 15). We propose that currently available free and open source software (FOSS) can fulfill many GIT requirements needed to improve disaster management capacity at the local level. While FOSS can create additional challenges compared to commercial solutions (Camara & Onsrud, 2004), with a clear understanding of the barriers and benefits of FOSS from a developing world perspective, FOSS is a capable and effective alternative.

In the first section of this review, we begin by laying a set of brief contextual explanations and definitions of natural hazards and disasters while emphasizing their spatial components, and then describe some of the factors that differentiate developed and developing countries from a natural disaster vulnerability standpoint. Included in this section is a more detailed examination of the most commonly cited GIT implementation barriers faced by developing countries. This is followed by a brief review of the phases that comprise the disaster management cycle. In the next section, which forms the bulk of this paper, we review the extensive literature that describes and explores the many uses of GIT in the field of natural disaster management. We then examine GIT-based FOSS, highlighting its potential as well as limitations in terms of its ability to fulfill disaster management related requirements. Finally, we discuss and describe our vision of how FOSS can greatly improve the ability of local level disaster managers to implement GIT, and thus improve overall disaster management capacity and reduce vulnerability to natural hazards.

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