GIS AND DISASTERS: PLANNING FOR CATASTROPHE

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Recent events, including the Indian Ocean tsunami, the hurricanes of the 2005 season, and the 7/7 and 9/11 terrorist attacks, have made us all acutely aware of the vulnerability of modern society. Knowing where such events have occurred and the geographic limits of their impacts is clearly important, particularly when combined with information on human populations, infrastructure, and other spatially distributed phenomena that may be relevant to response and recovery. But more generally, geographic information and the technologies that acquire, interpret, and disseminate such information (GIS, remote sensing, GPS, etc.) are clearly essential in all aspects of disaster, from preparedness, prevention, and protection through detection to response and eventual recovery. Geographic information and technology (GI&T) provide the basis for estimating and mapping risk, for planning evacuation routes and shelters, for determining areas where human populations are most likely to have been impacted following a disaster, and for assigning resources during recovery, among many other vital and important tasks.

In principle, investments made over the past decade in digital libraries, geoportals (Maguire and Longley, 2005), data warehouses, and the Internet that connects them and allows users to access them (see, for example, Peng and Tsou, 2003), should have created a world in which relevant data can be assembled quickly and easily following an event (Goodchild, 2003a). In reality, however, things are still far from ideal, and during the period of initial response access to GI&T is likely to be confused and ineffectual rather than smooth and efficient. The New York City emergency-management GIS was housed in one of the buildings destroyed on 9/11 and had to be re-established in the hours following the disaster. Communication links are often disabled, as they were over large areas of Louisiana and Mississippi after Hurricane Katrina. First-responders are often deluged by massive data sets provided voluntarily by agencies, corporations, and individuals in the hours following an event, but have no way of making effective use of them until power is restored, systems are up and running, and suitably trained staff are available. In reality no-one can anticipate the locations, scales, and intensities of disasters like these, or ensure that the necessary systems are hardened and that data to support response and recovery are accessible to everyone prior to or immediately after the event. Geographic data sets are often subject to licensing and access restrictions that cannot be arbitrarily ignored during disasters, and too few people on the ground are sufficiently trained to use them effectively.

Meanwhile GI&T continues to develop at an accelerating rate. High-resolution satellite imagery is now widely available, and sites such as Google Earth (earth.google.com) are able to make such data available in a matter of days through a simple interface that a child of ten could learn to use effectively in ten minutes. An abundance of wearable and

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mobile devices are available for use by workers in the field, with software and communication links that provide rapid access to carefully tailored data, and user interfaces that are suitable for use in the most difficult environments. UAVs (unmanned autonomous vehicles) can be flown with infrared sensors, though their use tends to be severely restricted by aviation authorities. RFID (radio-frequency identification) offers excellent potential for rapid tagging and identification of objects. There is even advanced work on low-cost sensors (*digital dust*) that can be distributed over an impacted area, and used to detect the presence of chemicals or fire (see, for example, www.cens.ucla.edu or firebug.sourceforge.net).

The case for GI&T in disaster management is clear and undisputed—they are essential in virtually all aspects. But in practice the case may be hard to make, and while one would expect such agencies as the U.S. Department of Homeland Security to have placed GI&T high on their agenda and to have featured them prominently in their research programs and organizational charts, in practice they are both everywhere and nowhere. While food, water, and shelter are clearly essential commodities in a disaster, it is difficult to make the same case for coordinates. Imagine, for example, arriving in a Sri Lankan village shortly after the Indian Ocean tsunami, and trying to interest desperately hungry villagers in the power of a GPS or a digital map (I am indebted to Andy Smith of MapAction for the basis of this comment).

In this context GI&T may be a hard sell, despite its indisputable relevance. Yet there is much that can be done to improve its usefulness and value, and to raise awareness of its power among institutions and decision-makers. The recent First International Symposium on Geo-Information for Disaster Management (GI4DM; www.gdmc.nl/events/gi4dm), held at Delft University in the Netherlands in March 2005, included a wide range of presentations and attracted approximately 500 registrants. A current study by the U.S. National Research Council, entitled Planning for Catastrophe: A Blueprint for Improving Geospatial Data, Tools, and Infrastructure, has six objectives:

"(1) assess the value of geospatial data and tools in disaster planning and disaster response;
(2) identify the status of and needs for decision-support tools that assimilate model predictions and data for mapping vulnerability to catastrophe, scenario testing, disaster planning, and logistical support;
(3) identify the mission-critical data requirements for effective decision-making;
(4) examine technical and institutional mechanisms that enable rapid discovery, access, and assemblage of data from diverse sources;
(5) assess training needs for developers and users of spatial decision-support systems; and
(6) examine potential conflicts between issues of security and the need for open access to data."

and will publish its findings in 2006 (further details are available at the National Academies website, www.nas.edu).

It will be clear to anyone familiar with GIS and disaster management that applications for virtually every GIS function can be found somewhere in this application domain. But one aspect distinguishes the domain from any other – the need for speed. Whereas GIS has often evolved in a project context, in which months and often years are consumed in preparing and assembling the necessary data and tools, disaster management applications require responses in hours if not minutes. The phrase *golden hour* is often used to describe the opportunities for saving lives that exist primarily in the first hour following an event, and decline rapidly thereafter.

In this context every aspect of a GIS project needs careful examination, from training and preparation to data gathering and product dissemination, to see whether critical bottlenecks can be removed. Even though the locations, scales, and intensities of events are almost impossible to anticipate, it is still feasible to build many elements of a GIS response in advance. Data models can be constructed, ready for population as soon as details are known (Goodchild, 2003b). Methods and scripts can be designed and programmed, based on databases that are yet to be populated but implement carefully constructed data models. Links to online sources can be regularly checked and updated.

It is also vital that we learn from the experience of previous disasters, by capturing and archiving the GI&T methods that worked, by documenting lessons learned, and by iterating designs and plans. Such practices are also comparatively rare in the world of GIS, where projects are usually designed to be executed, implemented, and then forgotten.

I have argued that GI&T is an essential part of disaster management, but that current GI&T practices and traditions developed in a very different context. Much needs to be done to bring them in line with the needs of disaster management, so that the benefits that GI&T can potentially offer in this application domain become realizable, and compellingly evident to institutions and decision-makers.

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