A STANDARDIZED FRAMEWORK FOR HAZARD MANAGEMENT MAPPING

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Abstract

As development in the world expands, the costs of natural and technological disasters keep escalating. For less costly and more effective response to these extreme events, our use of information before, during and after disasters must be enhanced. Hazard maps provide a unique organization of vital information for hazard identification, risk estimation and allocation of resources. They are a major support for emergency managers at all stages of a disaster. Hazard management mapping encompasses the entire domain of mapping found at the federal government and often in the private sector. A wide variety of maps are employed to identify the hazard itself, the degree of hazardousness, and results from screening and monitoring thereby providing the opportunity for a diagnostic overview. Other maps show the probabilistic risk in a given situation. In addition, the application of vulnerability maps have become popular in recent years. They often center on issues of health, economics or environment usually integrating data from many different sources to portray how vulnerable a given area is to one or several hazards. These maps supply support for planning before a disaster occurs.

However, currently, there are no unified guidelines for making these hazard maps. Each person charged with producing a new hazard map must develop content and design methods. Content and design not only differ between countries, but often within a government entity there is little map coordination. The lack of agreed upon symbolization, meanings of color ranges and other design characteristics does not provide a common ground for understanding maps in planning and in emergencies. Standardizing content and approach to design of hazard maps produced throughout the world will do much to enable managers to absorb vital information as efficiently as possible. The development of guidelines and standards for hazard mapping will illuminate communication between planners and will strengthen the ability of emergency managers to better understand information at a glance during crucial decision making moments.

Introduction

A natural hazard is defined as the probability of occurrence, within a specific period of time in a given area, of a potentially damaging natural phenomenon (Office of the United Nations Disaster Relief Coordinator, 1991). Burton and Kates (1964) defined such hazards as “those elements in the physical environment, harmful to man and caused by forces extraneous to him.” Natural hazards may be pervasive or intensive in habit and may originate from either biological or geophysical forces (Burton et al.1993), but all natural hazards have two major components - the physical component of the natural event and the human component (Tobin and Montz,1997). ”If an event neither affects nor damages humans, then such an event is referred to as a natural phenomenon. Natural hazards are different from natural disasters, as the former represents potential events whereas the latter results from actual events” (Tobin and Montz, 1997). Although virtually any environment is potentially hazardous to humans, there is actually a great geographical inequality in locations and impacts of natural disasters. The greatest differences are between the developed and developing worlds. Approximately 95 percent of deaths caused by natural hazards occur in developing countries (United Nations Environment Programme, 2000) while natural hazards rarely cause large numbers of deaths in industrialized countries. In 1998, natural disasters claimed more than 50,000 lives and resulted in economic losses of more than $65 billion (International Federation of the Red Cross and Red Crescent Societies of the World, 1999). Great inequities in death rates exist among nations. Recent hurricanes in the United States or typhoons in Japan have caused no more than 500 deaths per storm. The devastating category 5 Hurricane Andrew in 1992 caused less than 100 deaths in the United States while the number of deaths caused by weather hazards in developing countries is very high. In Central America, for example, category 5 Hurricane Mitch in 1998 alone caused more than 10,000 deaths. Likewise, the consequences of the Venezuela landslides were an estimated 30,000 deaths.

Large disasters are generally not isolated events. They are combinations of extreme events, one precipitated by another, each interacting with the other. Hurricane Mitch which hit Central America in the Fall of 1998 for example, caused significant flooding, storm surges, and wind damage. It also caused secondary and tertiary disasters such as landslides and mudflows, crop failures, spread of disease, hunger and starvation, infrastructure failure and social and economic dislocation (Kelmelis et al, 2000). Part of the responsibility for failure in dealing with disasters in the developing world belongs to political decision makers for ignoring constant warnings about risk. At the same time, the scientific community bears the responsibility of conveying vulnerability in a way that captures the attention and interest of decision makers. Hazard mapping needs to be an integral part of this effort (Sancio et al, 2000).

Information Technology Transfer

Clearly, no society is immune to threats from natural disasters. As the risk continues to grow, it is imperative that the most recent technological advances be harnessed to aid the disaster manager in reducing loss of life and property. Advances in communication, remote sensing and computing capabilities now enable the sharing of information as never before. Advances in information technology have dramatically transformed the way in which our entire society lives, works, learns, communicates, and does business. Throughout the world, however, these technological advances are only available to a small percentage of society. Specifically, the way we conduct science and engineering is important to the transfer of technological advances to developing countries. Through educational programs local officials and managers can learn how to apply the most up-to-date technology for better decision making, especially for managing disaster situations.

In 1996, the Natural Disaster Reduction Plan was prepared by the National Science and Technology Council Committee on the Environment and the Natural Resources Subcommittee on Natural Disaster Reduction in the United States. This strategic plan clearly states that risk assessment is the necessary starting point with which to identify the resilience needed in society and the sort of overarching mitigation strategies that must be implemented to strengthen societal resilience to hazards. Such an effort is essentially spatial and requires maps as research and planning tools.

Mapping and Disasters

It is commonly assumed that a map is a concrete object. However, people construct mental maps out of an aggregation of the input from their senses over time as they experience and interact with the environment or space (Liben et al., 1981; and Lynch, 1960). Dent (1999) defined mental maps as "mental images that have spatial attributes." According to Gould and White (1986), and Downs and Stea (1973), these images vary markedly between individuals and are influenced by each person's social class and location. MacEachren (1995) described the gradual developmental process whereby adults gather information from the environment. Proceeding from an initial spatial framework, details about an environment are subsequently incorporated into an individual's mental framework. MacEachren suggests that the location of landmarks and routes is a major feature of the cognitive learning process. It follows that newcomers will have less recall about an area compared to long-term residents. The diversity of mental images employed by decision makers during any disaster may be a critical ingredient in the way the disaster is managed (Dymon and Winter, 1991)

Any aspect of disasters and hazards can be mapped, providing there is sufficient information on its distribution. In this respect, the aspects most often mapped are: 1) the pattern of manifestations of the geophysical agents that cause disasters, 2) the spatial distribution of their impacts and 3) the distribution of human vulnerability. It is also possible to map emergency response and the viability of routes and lifelines after disasters. One way of increasing the power, potential and flexibility of hazards mapping is the application of Geographic Information Systems (GIS). GIS is a complex computer system that stores, manages, analysis, models and displays geo-referenced data (McHarg, 1998). GIS as it has evolved reflects the ascendancy of practices based on specific suites of techniques of data overlay that provide the keys of geographic integration, vital to hazard and disaster mapping.

The U.S. Federal Emergency Management Agency (FEMA), responsible for response to disasters in the United States, has developed comprehensive event specific Information Collection Plans that were developed by the Rapid Assessment Work Group (FEMA, 1999). These plans provide detailed information on a potential emergency event itself; for example, on a hurricane. Listings of contacts and specific information required to deal with the event are described in each plan. Similarly, scientists at other federal agencies such as the United States Geological Survey (USGS) provide guidance to others for data collection methods and analysis, as in the case of seismic hazards whereby Hanks and Cornell (1994), and Randall, et al, (1998) outlined methods for landslide hazard maps. Others have produced similar guidance for specific types of maps, such as the National Flood Insurance Program. What is needed are guidelines and standards which encompass the entire area of Hazard Management Maps

A Framework for Hazard Management Maps

After collecting data on the types and numbers of maps used and produced during several disasters and hazardous events an overall statement about hazards maps can be made.
Information collected included:

Base Maps:
These maps or images, as their name suggests, furnish basic information about the topography, political boundaries, highways and the location of settlements. Good base maps are essential in any disaster situation. They can be used for any type of mapping within the affected area.

Hazard Maps:
Used to identify the hazard, these maps locate the hazard by revealing the spatial patterns of past disasters. They are essential for research, screening, monitoring and diagnostic work and serve as guides for mitigation efforts against future impacts. Hazard maps can be digital remote sensing images.

Risk Maps:
These maps quantify the probability and degree of consequence of potential victims or damage. The scales of these maps are tremendously important, the larger the scale the closer the risk zone.

Disaster Management Maps:
The majority of these maps relate to past events or impacts not to the crisis as the name suggests, since these maps evolve. They can be found in four orders according to Alexander (1995).

First order - *Observational maps* involve the hazard assessment in terms of impact to society.
Second order - *Engineering maps* are used during the reconstruction stage of rebuilding the community.
Third order - *Interpretive maps* show the hazards and risk zones in terms of suitability for occupancy.
Fourth order - *Planning maps* which delineate recommended adjustments and guides for a safer

community or important policy changes, such as land use change.

Another approach to the same mapping problem was proposed by Winter (1997). She also suggested four categories of maps, but to handle the final stage of recovery efforts, she proposed the utilization of time series maps which suggest the dynamic changing nature of the physical agent (the disaster), the process of infrastructure reconstruction and the social rebuilding of the community. Her four stages include maps:

For preparedness - *Planning maps* are needed.

During the crisis - *Crisis maps* evolve during the event to control the physical agent causing the disaster.

For emergency response - *Response maps* are prepared for use by emergency workers.

Recovery - *Time series* maps are prepared to show changes in the physical agent, the process of infrastructure reconstruction and the social rebuilding of the community.

Winter also proposes that any of these maps can be used for risk communication through the media to the public. This is an essential part of the disaster mapping process since the media provides necessary updates of the event to outsiders and emergency workers.

Summary and Conclusions

Hazard management mapping encompasses the entire domain of mapping found at the federal government and often in the private sector. A wide variety of maps are employed to identify the hazard itself, the degree of hazardousness, and results from screening and monitoring thereby providing the opportunity for a diagnostic overview. An examination of maps and literature points to a need for standardized approaches within the realm of hazard mapping. The developed world should take the lead in this undertaking to provide procedural and technological assistance to developing countries.

The development of guidelines and standards for hazard mapping will foster communication between planners and policy makers and will strengthen the ability of emergency managers to better understand information at a glance during crucial decision-making moments. More generally, mapping guidelines and standards will aid, especially in the developing world, in the undertaking of systematic research to decrease disaster vulnerability and to identify future sustainable development. Guidelines are needed more at this scientific level of hazard and disaster management than at any other.

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