Understanding of Natural Disaster Database Design and Compilation of Digital Atlas of Natural Disasters in China*

Peijun Shi, Jing'ai Wang, Mingchuan Yang, Jin Chen, Yaozhong Pan, Ping Wang, Weihua Fang, Wuguang Zhou, Ying Wang, Yi Yuan, Xia Xu and Wei Luo§

Key Laboratory of Environmental Change and Natural Disaster, The Ministry of Education of China
School of Resources and Environmental Science, Beijing Normal University. Beijing, 100875
§Geographic Information Science Center and Departments of Landscape Architecture and Environmental Planning
102 Wheeler Hall, University of California, Berkeley, Berkeley, CA 94720-2000

Abstract

Many disaster databases were built in Key Laboratory of Environmental Change and Natural Disaster, The Ministry of Education of China, in the last decade. These disaster databases can be grouped into 3 categories: statistics-orientated, system-orientated and process-orientated. In order to distribute the data and scientific results of natural disaster research of the laboratory, an interactive multimedia atlas system, *Digital Atlas of Natural Disasters in China*, was developed from 1999 to 2000. The atlas system takes advantage of different media to help human cognition and communication. The basic disaster information, information about flood disasters, and information about earthquake disasters are included in the atlas system.

I. INTRODUCTION

China has one of the greatest frequencies of natural disasters. The economic loss due to floods, droughts, earthquakes, and sandstorms, and its proportion to GDP keeps increasing in recent years. The direct economic loss due to natural disasters was 77.9 billion Yuan (about $9.4 billion) in 1991 and it rose to 225.1 billion Yuan (about $27.5 billion) in 1998.

Key Laboratory of Environmental Change and Natural Disaster, the Ministry of Education of China, was founded in 1988 and committed to the disaster databases construction and disaster study. Many natural disaster databases are built during the last decade of its development. These natural disaster databases are essential in helping understanding of the disaster distribution in China, the disaster system, and the mechanism of disasters.

In order to share the data and spread the scientific results of its disaster research in China, the *Digital Atlas of Natural Disasters in China*, a GIS-based interactive and multimedia digital atlas system, was developed from 1999 to 2000.

II. DISASTER DATABASE DESIGN

According to the experience of the key laboratory, the natural disaster database design has gone through 3 phrases, beginning with the statistics-oriented, and then the system-oriented and then the mechanism-oriented databases. The system-oriented databases were built according to the disaster system theory (Shi, 1991, 1996). The process-oriented databases concentrated on exploring the mechanism of natural disasters. The progress of disaster database design is a measurement of the progress of the disaster science. Today, these disaster databases serve as the cornerstone of Digital Atlas of Natural Disasters in China (Figure1).

Statistics-oriented disaster databases

The *theory of disaster system* didn't exist in the early stage of the natural disaster research and case study of natural disasters was still under development. The database built in this period mainly aimed at calculating disaster statistics and the accompanying economic losses. The statistics-oriented disaster databases record attributes of natural disasters in the most disastrous areas. Most databases at that time used dBase or FoxBase in the Dos system. (Chen, 1992). The geographical distribution of natural disasters can be reflected in these databases.

The representative databases in this phase are *Agricultural disasters in Hunan Province*, *Agricultural and pastoral disasters in Inner Mongolia Autonomous Region*, and *Natural disasters of each province in China* (Table 1)(Wang *et al*, 1999; Pan *et al.*, 1997; Wang *et al.*, 1995).

System-oriented disaster databases

The theory of disaster system, a milestone of the natural disaster research, came out in 1991. The theory

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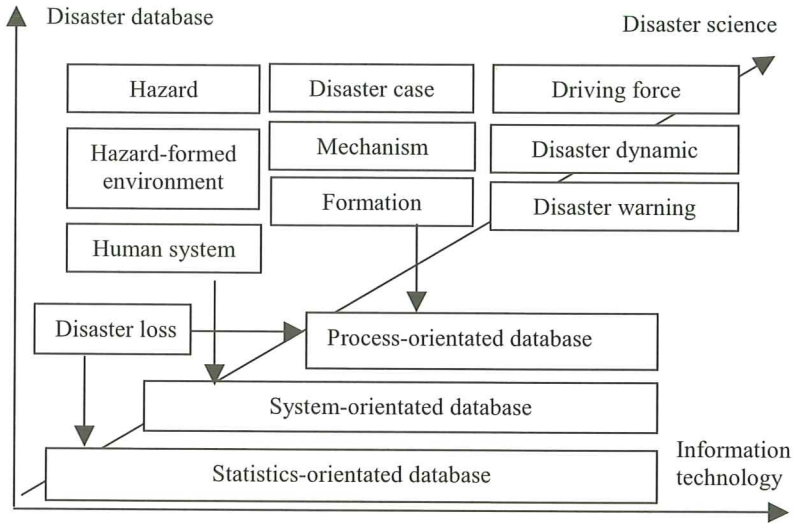


Figure 1. Interaction between the progress of IT, database design and disaster science

states that a disaster system consists of 3 components: the hazard system, the hazard-formed environment and the human system. The theory explored and expounded the inter-relationship between the components and their impacts on disaster induced losses (Shi, 1991, 1996). According to this theory, the goal of building natural disaster databases is to record the attributes of the hazard-formed environment, the hazard system, the human system and disaster losses, and to help understanding the relationship between them.

In order to reflect the disaster system, the disaster-homogeneous areas, or the basic spatial units, were created. The basic spatial units were formed by overlaying hazard, hazard-formed environment and human system, and then disaster losses were allocated to each basic unit (Figure 2).

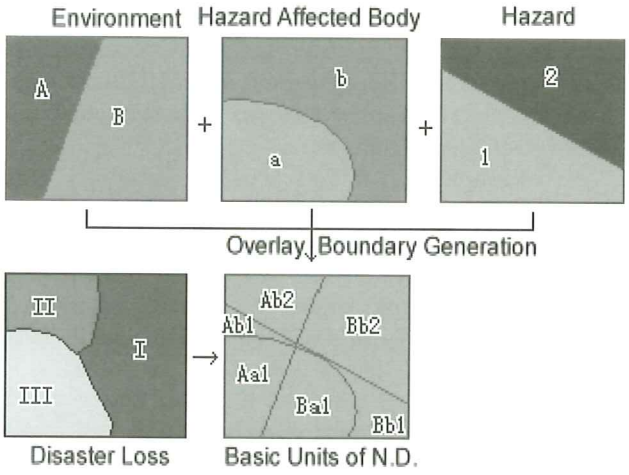


Figure 2. Generation of Natural Disaster Basic Units

The representatives of the system-oriented databases are *Large area natural disaster insurance in Hunan Province, Comprehensive listing of agricultural disasters in Hunan Province* (Table 1). The supporting software is Visual FoxPro.

Large area natural disaster insurance in Hunan Province includes remote sensing data, land use maps and digital elevation model (Pan *et al*, 1997). However, the application of this system-oriented database is limited to cropland areas and is constrained by the insufficiency of the hazard description.

Comprehensive agricultural disasters in Hunan Province introduced the disaster effect factor into the analysis when forming the basic spatial units of disaster (Wang *et al.*, 1999). This database was also used to study the disaster regionalization.

Historical flood disaster in 7 main drainage basins in China, also a system-oriented database, used data of 176 years from 1736 to 1911, and the county boundary as the spatial unit (Fang *et al.*, 1998). The spatial patterns of the historical floods in different periods were reconstructed using geo-statistics tools. Flood risk in Yangtze River Drainage Basin was assessed based on the historic flood series data. However, the mechanism of flood disasters remains unresolved in this database, due to the limitation on accuracy of historical documents.

Process-oriented disaster databases

With the progress of the *theory of disaster system*, the mechanism of natural disaster became the focus of natural disaster research. The above statistics-oriented and system-oriented databases, however, can

Table 1. Types of Disaster Databases

Type	Contents	Completing Time	Supporting software
Statistics	*Agricultural and pastoral disasters in the Inner Mongolia Autonomous Region*	1991	dBase, FoxBase Dos System
	Agricultural disasters in Hunan Province	1993	FoxPro for Windows
	Natural disaster losses in rural areas of China	1994	Windows System
	Indemnity cases of natural disaster insurance in Hunan Province	1995	
	Historical floods and drought disasters	1996	
	Natural disasters in each province in China	1995	
System	*Agricultural disasters in Shanxi Province*	1994	Visual FoxPro
	Large area natural disaster insurance in Hunan Province	1997	GIS System (Arc/Info; MapInfo)
	Emergency management for the natural disaster insurance	1998	
	Comprehensive listing of agricultural disasters in Hunan Province	1999	
	Historical flood disasters in 7 main drainage basins of China	1999	
Process	*1998 flood in China*	1999	Sybase
	Precipitation-runoff-flood in Shenzhen City	2000	GIS System

neither reflect the formation and the development of natural disasters, nor can they explain the process of natural disasters and hence cannot explain the mechanism of many disaster cases.

The process-orientated disaster databases, with an emphasis on the development process of natural disasters, record the whole process of each disaster case. A process-oriented database may be composed of several natural disaster cases, and form a holistic description of the disaster process. Databases for the 1998 flood disaster in China and Precipitation-runoff-flood in Shenzhen City are 2 tentative examples of process-orientated databases (Table 1).

III. COMPILATION OF *DIGITAL ATLAS OF NATURAL DISASTERS IN CHINA*

Digital Atlas of Natural Disasters in China integrated the multimedia technologies to represent spatial data. The atlas not only displays information, but also is an interactive tool for analyzing and understanding the natural disasters in China (Table 2). Unlike the conventional static and isolated representations of disaster information with hardcopy maps, all the vector maps in the atlas were created directly from the existing databases, thus if the databases are updated the maps may be updated at the mean time. Some maps are linked to text explanations, pictures, satellite images, sounds or videos of the corresponding disasters. Functions of different media in human cognition and communication process were considered carefully in the atlas. Users can find any map through a file browser or using a Structural Query Language (SQL) expression that supports fuzzy match.

Contents of the atlas

The atlas has 571 maps and 104 tables in total, which can be grouped into three categories: information for the disaster background (preface), the flood disaster information, and the earthquake disaster information. The preface has 34 maps (19 maps about hazard-formed environment and 15 maps about natural disasters). There are 341 maps and 104 tables about flood disasters, with 77 maps and 24 tables of the whole China, 48 maps and 58 tables of different drainage basins, and 216 maps and tables of most of the provinces of China. The atlas also includes 196 maps with 71 maps of earthquakes, with 29 maps at the regional scale and 96 maps of earthquake case studies.

Workflow of the atlas

The workflow of the atlas is shown in Figure 3.

Cartography generation, symbol system and Information communication

The principal question of cartography integration regarding the digital atlas is the definition of the cartographic basic units, also known as the basic spatial units, which store large amounts of natural disaster data. The scale of the spatial unit will determine the spatial resolution or the precision of natural disaster information. There are 2375 counties in China, which serve as the basic economic and disaster loss unit in China. Most of the above databases are built with county as the basic spatial unit. Therefore, *Digital atlas of natural disasters in China* uses the administrative county boundary as the basic cartographic unit.

There are 2 major map generation methods used in

Table 2. Symbol language system of *Digital Atlas of Natural Disaster in China*

Data Source	Language Type		Map Language Controls	Phenomenon of Natural Disaster
Data	Map Symbol	Grade Graphs District Graphs Dynamic Chart Point Symbol Animation Data House	Set Grade Set Color Set District Set Layer	• Qualitative and quantitative display of natural disasters • Overlaying and dynamic display of the natural disaster system • Map renew of natural disasters • Regional distribution rule of natural disasters
Digitizing	Text	Character Table	Hot-link Area Set Layer	• Qualitative and quantitative description of natural disasters
	Sound	Voice Sound Music	Switch Control Show in time Show in select	• Live sound of natural disaster's bursting out, such as: flood, fire, rainstorm's sounds, etc • Solemn music related with the disaster • Easiest music used to release mood
	Graphics	Graphics Pictures	Hotlink Area Set Layer	• Mechanism of the natural disaster system • Statistics of natural disasters
	Map Symbol	Linear Symbol Area Symbol Point Symbol	Static layer, and dynamic show (flash, move, appearance, etc)	• Distribution of the natural disaster type, and its routine moved away • Alert of heavy natural disasters • Spatial differentiation analysis of natural disasters
	Anima-tion	Modular Cartoon Map AVI	Dynamic process display Dynamic control display (Interactive)	• Roam of spatial natural disasters • Dynamic processing of mechanism of natural disasters • Dynamic processing of changes of natural disasters
	Picture	Landscape Air Photo Space Image	Zoom and Roam Set Layer	• Observation and monitoring of natural disasters • Effects of natural disasters
	Video	Video segment	Button control or automatic show	• Spot condition of natural disastesr process
Interactive			Interface Control	• Human-PC's interactive operation of analysis with atlas of natural disasters
Encoding			Interface Control	• Personalization of analysis with atlas of natural disasters

the atlas system. The first method generates maps by classifying the disaster index. During the classification process, the pre-defined statistical methods and the customized methods are used to reflect the geographical principles of natural disasters.

The former methods include equal range size, equal count per range, standard deviation and custom ranges. For example, the frequency and the risk generation should be consistent with the spatial and temporal principles of natural disasters. In general, this method is used in producing conventional hard-copy maps.

The second method is to control and change the properties of each map layer. For instance, the display styles of a layer can be modified by changing the color and size of lines or polygons, and the fill pattern of areas; switch how and where the labels located; whether a layer is visible at a certain map scales. Thus, when map users zoom in to bigger scale, more information, such as additional layers or labels may be added to the display automatically. On the other hand, when users zoom out, the atlas system can turn off parts of a layer or some layers from display. Therefore, the displayed contents in a map may change according to the scale of the map dynamically and automatically. Both map editors and map users can control the way of map generation.

The information communication model of the digital atlas of natural disasters in China explains the communication process between map editors and map users, based on the regional natural disasters system and the theory of cartography communication (Figure 4). Compared to conventional maps, the digital atlas has three major advantages. Thematic maps are generated directly from data sets and maps are linked

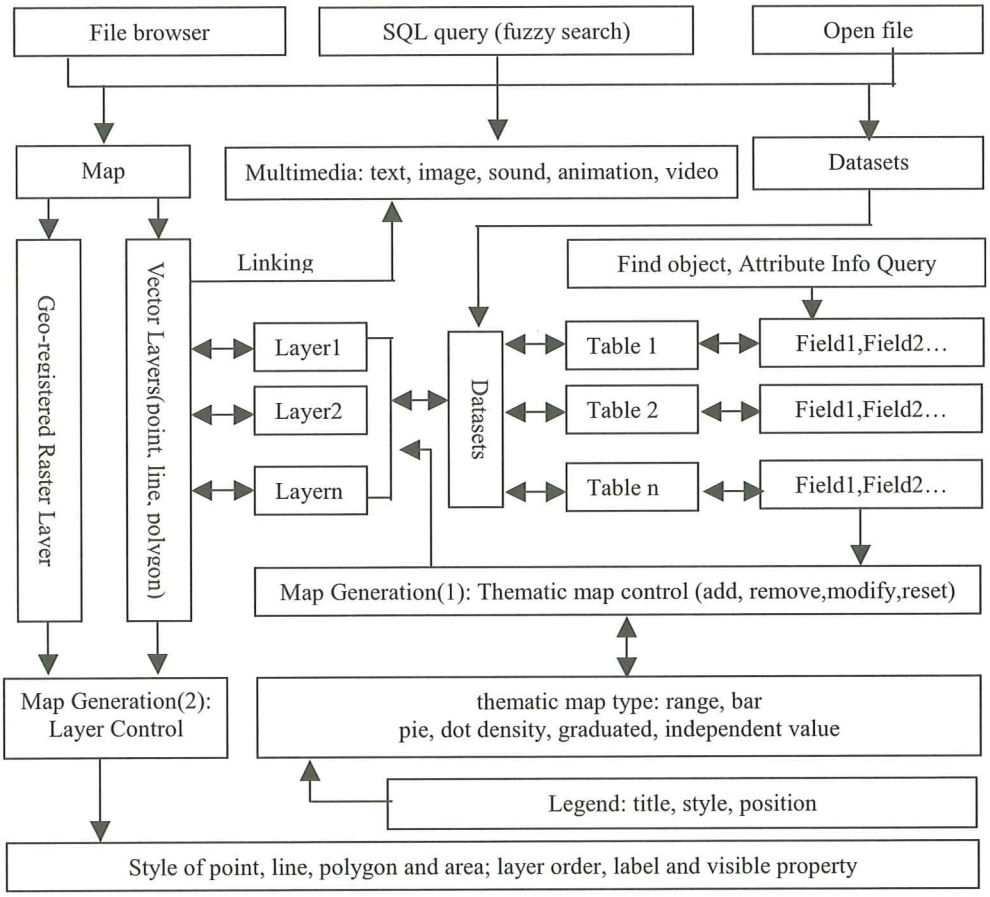
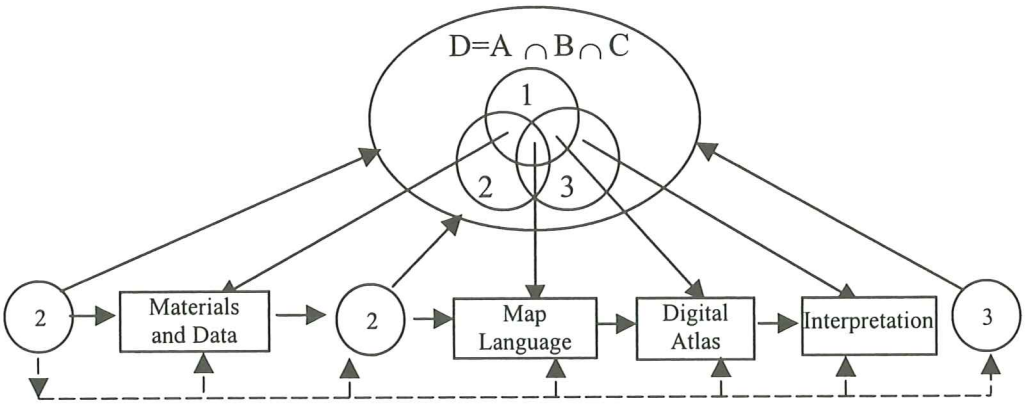


Figure 3. Workflow of digital atlas of natural disasters in China

to multimedia. It is an interactive system, not a conventional view-only system. Cartographers and map users can change their roles. Map users can modify maps or generate new maps based on the existing data. It is also an analytical system. Users may re-analyze the distribution rules of natural disasters, and form their own understandings of natural disaster from the analysis.

IV. CONCLUSION AND DISCUSSIONS

The goals of 3 types of natural disaster databases—statistics-oriented, system-oriented, and process-oriented—are different. The evolvement of disaster database design reflects the progress of the disaster sci-



1 Atlas Editor *2* Cartographers *3* Map-reader
A: Hazard-formed environment *B*: Hazard *C*: Human system *D*: Disaster
---> Information communication of Disaster ------ Interaction between Users and Atlas

Figure 4. Information Communication Model of Digital Atlas of Natural Disasters

ence. The statistics-oriented databases aim at the study of spatial distribution of disasters. The system-oriented databases were built according to the theory of the disaster system. The primary task of the system-oriented databases is to record the attributes of the hazard-formed environment, the hazard system, the human system and disaster losses, and also help understanding the relationship between them. The process-oriented database concentrates on exploring the mechanism of natural disasters.

According to our experience, the information technology not only increases our efficiency and capabilities in analyzing data of natural disasters, but also stimulates the science of natural disasters. At the same time, the achievements of the natural disaster research call for innovations of in IT, which can contribute to a better understanding of the natural disaster science.

Digital Atlas of Natural Disaster in China, a GIS-based, interactive and analytical multimedia system was developed. The 3 types of natural disaster databases are included into the atlas. The data and scientific results on disasters in China included in the atlas are not only valuable for disaster scientists and policy-makers, but also beneficial for individuals, households, and companies.

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