Practice of establishing China's Geo-Hazard Survey Information System

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ABSTRACT: Based on the geo-hazards survey of seven hundred counties in China, with each county as a unit, the Geo-Hazard Survey Information System gathers national geo-hazard survey information and provides the functions of statistical analysis and assessment. The system contains a fundamental geo-hazard database, which is the most complete in the nation. The database includes geo-hazard information such as landslides, rockfalls, debris flows, ground fissures and unstable slopes and so on. The amount of survey information of geo-hazard locations and hidden danger spots in the database is more than one hundred thousand. The significance is to reduce the geo-hazard loss as much as possible by finding out the current situation and the development trend, assessing the situation of geo-hazards and danger, identifying the susceptible regions and the dangerous regions and hence suggesting prevention plans and arrangements.

1 INTRODUCTION

With the development and application of information technology, geologic information can be used not merely for intuitionistic browsing and simple visual judgment but for comprehensive analysis and application. The traditional information communication mode is unable to adapt to the requirements for information gathering. It requires an entire solution, including data processing, data management, information analysis and information publication. By the means of information technique, the solution can manage and analyze the information combining data and geologic information, which can make decision intuitively by adding geographical analysis to various information systems and discovering implicit relations, rules and changing trends. The Geo-Hazard Survey Information System is an efficient method for achieving this.

Since the geo-hazard warning project was launched, we have carried out geo-hazards surveys and developed regional plans in seven hundred counties. The rationale is that it reduces the geo-hazard loss as much as possible by finding out the current situation and the development trend, assessing the situation of geo-hazards and danger, identifying the susceptible regions and the dangerous regions and hence suggesting prevention plans and arrangements, advancing the monitoring network and combining experts, using a county as the basic unit. The Geo-Hazard Survey Information System, which is based on the survey and GIS platform, gathers national geo-hazard survey information and provides the functions of statistical analysis and assessment. The database includes geo-hazard information such as landslides, rockfalls, debris flows, ground fissures and unstable slopes and so on. The amount of survey information of geo-hazard locations and hidden danger spots in the database is more than one hundred thousand.

The system results in a geo-hazard database, which is the most complete in the nation. The establishment and improvement of the database provides rapid and valid information services for geo-hazard prevention and control and national geo-environment management. Meanwhile, it accelerates geo-hazard survey, monitoring, prevention and control.

2 MAIN FRAMEWORK OF THE SYSTEM

The system bases the main workflow of geological survey on information, made up of information gathering, information transmission, information processing and information services. The system provides the corresponding functions according to the application demand of the users. The main functions include data input, field data collection, data quality control, data summary, data management, data query, data statistics, data publishing and data display and so on. The system has three modules: data collection module, data management module and data service module. The main framework of the system is shown in Figure 1.

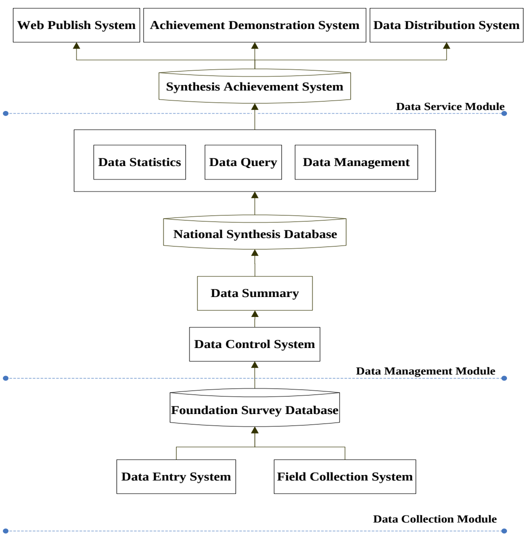

Figure 1. The system main framework

Every function is designed for specific users and usage stages. The data collection module is mainly used to collect data, edit data and enter it in the library according to system requirements and a unified data collection standard, to ensure data consistency and integrality, thus providing a solid foundation for the following multiple utilization of data. The data management module can be mainly used at the stage of summary and application of data. It can summarize survey data of different regions and provide the function of query, statistics and auxiliary processing for data managers and users. It manages data effectively and provides powerful technology support for data synthesis application and development. The data service module provides services for different data users. It can publish synthesis data, show thematic data and distribute custom data.

The query and statistics functions provide powerful technology support for comprehensive analysis of geo-hazards. The auxiliary processing can generate many types of statistical distribution maps. An example is the the geo-hazard distribution map of developmental degree, as shown in Figure 2.

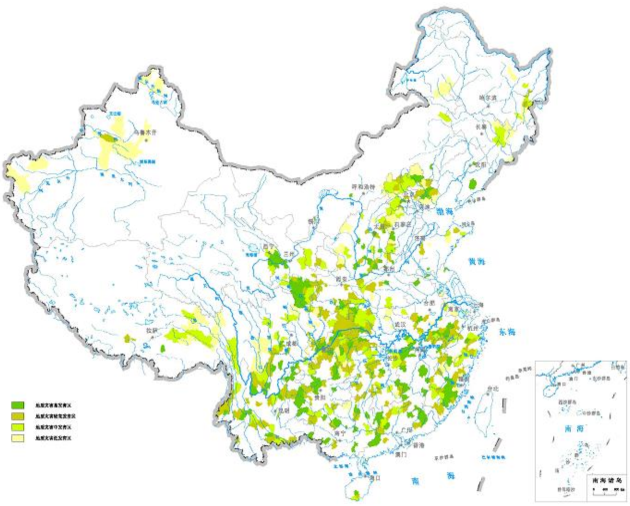

Figure 2. The geo-hazard distribution map of developmental degree

The system can take statistics conveniently and reproduce the result data as a set of diagram.

(1) Statistical diagram of the geo-hazard occurrence time

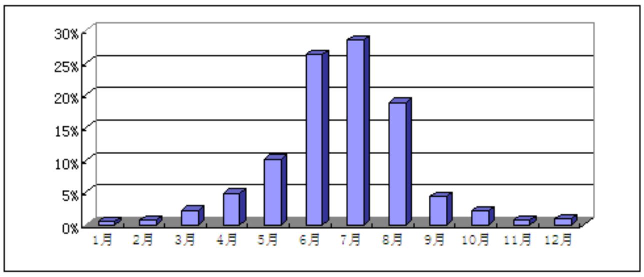

Figure 3. Statistical diagram of the geo-hazard occurrence time

(2) Statistical diagram of the geo-hazard scale

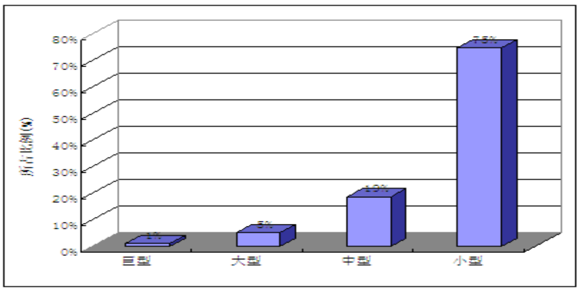

Figure 4 Statistical diagram the geo-hazard scale

(3) Statistical diagram of landslide type

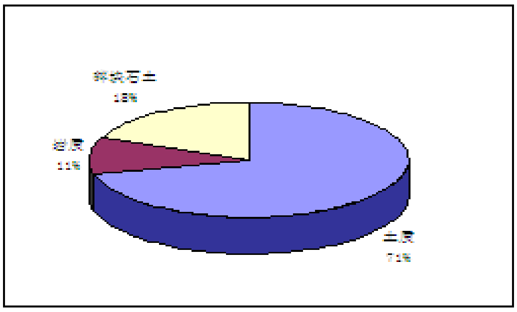

Figure 5. Statistical diagram of landslide type

3 SYSTEM DATA MODEL

To collect, manage and apply geo-hazard survey production data are the main functions of the system. The data includes landslide data, rock fall data, debris flow data, sinkhole data, ground fissure data, hidden hazard data (unstable slope) and so on. It also includes production reports and correlative production diagrams.

The core of the system is data. Data modeling is the key to how to organize and manage data so that the system can express the geo-hazard phenomena completely, then, users can query, process and analyze data conveniently. The design of the geo-hazard data model adopts a method combining classic modeling and object-oriented modeling. The data model allows different thematic elements to be abstracted from some thematic layers in the form of points, lines and polygons. By internal attribute correlation, the geo-hazard object-entity attribute is correlated. Then both organization and management of space data and consistency of multi-data are assured, so that GIS and database system show the advantages for spatial information management.

By researching the application characteristics of GIS in a professional field, the system modeled national geo-hazard data and provides a solid foundation for professional fields. The geo-hazard data model is shown in figure 6. For designing the data model, we considered the following characteristic of geo-hazard survey information sufficiently.

(1) Performance Characteristics of Analyzing and Processing

The purpose of the geo-hazard survey information is the comprehensive analysis and utilization of data, especially of spatial information. For data related spatial analysis, the size is very huge and the sources are multiple.

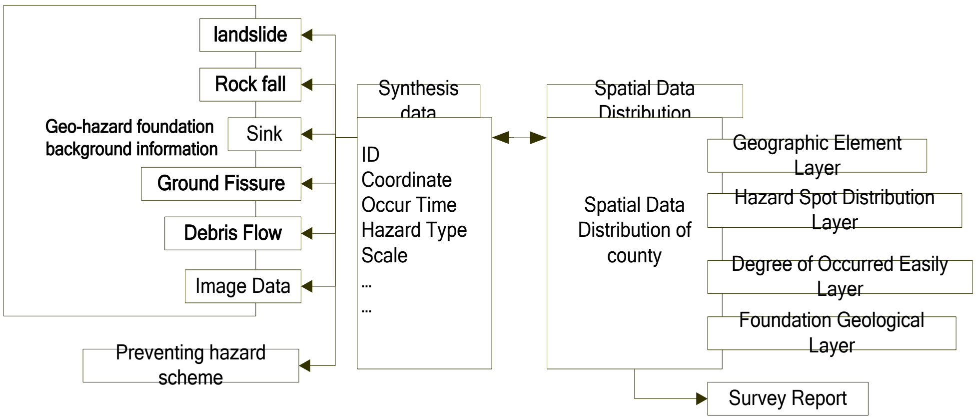

Figure 6. The geo-hazard data model

Spatial analysis takes up lots of time, but it is not a simple data query. Therefore considering the availability of data is essential.

(2) Integration Characteristics of Multi-data
The geo-hazard survey information contains vectors which describe spatial distribution, geo-hazard spot attribution, unformatted documents and images. For valid analysis and decision it is the initial premise that the multi-data is integrated and managed. The more completely the related data collected and the closer the connection is, the more credible the result is.

(3) Dynamic Characteristics of Data
The managed data is finished by survey only once, but geo-hazard spot may change with time. Thus the dynamic characteristic of the data should be considered when designing the data model.

(4) Comprehensive Characteristics of Data
The current survey achievement is mainly fundamental information, including a great deal of data which reflects geo-hazard feature details. But this detailed data is not analyzed. It is necessary to synthesize the detail data to get useful information before analysis. Therefore, to synthesize data and extract data conveniently are necessary, meanwhile data mining and data aggregation should be supported.

The landslide data structure table is shown in Table 1. The rock fall data structure table is shown in Table 2.

4 DATA QUALITY GUARANTEE

With the geo-hazard survey, we have developed the information system gradually since 1999. All departments participated in the work. So the quality of the system is particularly important. The outcome of having incorrect or inaccurate information is an incorrect or inaccurate result and corresponding decision. As a result, loss could be huge. Therefore the data quality guarantee is very crucial.

The system implementation conforms to ***The work guide of geo-hazard survey information system construction*** and ***The standard of geo-hazard data quality control***, by researching IS0 9000 19113 and 19114, and by referring to DZ/T 0179-1997, DZ/T0160-95 and ***The work guide of geological map spatial database construction (2nd edition)***.

Based on geo-hazard data characteristics, the factor system of data quality was established, including Level 1 quality elements, such as data integrality, logic consistency, spatial location accuracy, thematic data accuracy and map decoration appropriateness, and Level 2 quality elements. The factor system of data quality is shown in Table 3.

Table 3. Factor System of Data Quality

Level 1 quality elements	Description	Level 2 quality elements	Description
data integrality	Entity, entity attribute, entity relationship exists or not	redundant	redundant degree of data in a data set, such as redundant layer, spatial entity
		absence	absence degree of data in a data set, such as absence layer, spatial entity
logic consistency	consistency degree of logic rule about data structure, attribute and relationship	concept consistency	consistency degree to structure design, such as to database structure design
		domain consistency	consistency degree of value to domain, such as consistency of relationship to other domain
		format consistency	match degree about data storage to physical structure of data set，such as data file name or data format
		topology consistency	accuracy of topology feature, such as polygon close or not, node relation correctness
spatial location accuracy	Accuracy of spatial entity location	Math foundation Accuracy	Accuracy of map contour spot, point of intersection on coordinate system and reference point coordinate, Accuracy of coordinate, height datum, parameter and map projection
		emendation Accuracy	rationality of number and distribution of reference spot, accuracy degree of projected data
		collection accuracy	accord degree of spatial entity location to acceptable value or real value, such as scan and vector precision, spot spatial data location precision
thematic data accuracy	Accuracy of ration attribute, accuracy of qualitative attribute, entity and attribute classification	classify accuracy	accord accuracy of entity and its attribute classify to real value or a reference data set
		qualitative attribute accuracy	such as input accuracy of hazard spot attribute
		ration attribute accuracy	such as accuracy of value
map decoration appropriateness	Configuration of color, pattern, symbol and line type, Specification of map name, map number, legend, figure and inlay	Symbol appropriateness	correct symbol, accuracy location, reasonable denotation, symbol and symbol, relationship rationality of symbol to symbol and symbol to other map member
		Line appropriateness	correct line type, lubricity line
		Color appropriateness	appropriateness of professional color palette standard and rule
		pattern appropriateness	pattern type, color, height, width and transparent coefficient is correct or not
		Graph Structure rationality	measure map contour contain and appearance, reasonable map structure, handsome
		annotation appropriateness	Correct and readable annotation, rationality of parameter and boundary relation

Table 1. Landslide Survey Data Structure Table

Field name	Data type	Required	Description	Unit
ID	Char	Yes	●	
Project name	Char	No		
Mapsheet name	Char	No		
Mapsheet ID	Char	No		
Name	char	Yes		
Field ID	char	Yes		
General ID	char	Yes		
Location	char	Yes		
GPS longitude	Single	Yes	●	degree
GPS latitude	Single	Yes	●	degree
GPS altitude	Single	Yes	●	meter
longitude	Single	Yes		degree
latitude	Single	Yes		degree
Top of slope	Single	Yes		meter
Foot of slope	single	Yes		meter
Slide time	char	Yes	single select	
Occurring time	char	No		
Landslide type	char	Yes	single select	
Landslide property	char	Yes	single select	
Stratum epoch	char	Yes	single select	
Stratum lithology	char	Yes	multi select	
Stratum incline	int	No		degree
Stratum dip angle	int	No		degree
Structure location	char	No		
Seismic intensity	char	Yes	single select	
Micro topography	char	Yes	single select	
Ground water type	char	Yes	multi select	
Annual rainfall	single	No		millimeter
Max day-rainfall	single	No		millimeter
Max hour-rainfall	single	No		millimeter
Flood level	single	No		meter
Low water level	single	No		meter
Location to river	char	Yes	single select	
Origin slope height	single	Yes		meter
Origin slope gradient	single	Yes		degree
Slope type	char	Yes	single select	
Slope structure type	char	Yes	single select	
Length	single	Yes		meter
Width	single	Yes		meter
Thickness	single	Yes		meter
Area	single	Yes		Square meter
Volume	single	Yes		Cubic meter
Landslide slope gradient	Integer	Yes		degree
Landslide slope aspect	Integer	Yes		degree
Plane shape	Char	Yes	single select	
Section shape	char	Yes	single select	
Slide body lithology	char	Yes	multi select	
Slide body structure	char	Yes	single select	
Gravel content	char	No		%
Size of block	char	No		centi meter
Slide base epoch	char	Yes	single select	
Slide base lithology	char	Yes	multi select	
Slide base incline	Integer	Yes		degree
Slide base dip angle	Integer	Yes		degree
Slide plane shape	Char	Yes	single select	
Slide plane buried depth	Integer	Yes		meter
Slide plane cline	Integer	No		degree
Slide plane dip angle	Integer	No		degree
Slide zone width	single	No		meter
Slide zone soil name	char	No		
Slide zone soil property	char	No		
Ground water buried depth	single	No		meter
Ground water out crop	char	No	multi select	
Supply type	char	No	multi select	
Land use	char	Yes	multi select	
Structural area type no.1	char	No		
Structural area incline no.1	Integer	No		degree
Structural area dip angle no.1	Integer	No		degree
Structural area type no.2	Char	No		
Structural area incline no. 2	Integer	No		degree
Structural area dip angle no.2	Integer	No		degree
Deformation name no.1	Char	No	single select	
Deformation location no.1	Char	No		
Deformation feature no.1	Char	No		
Deformation time no.1	Char	No		
Deformation name no.2	Char	No	single select	
Deformation location no.2	Char	No		
Deformation feature no.2	Char	No		
Deformation time no.2	Char	No		
Geological factor	Char	Yes	multi select	
Topography factor	Char	Yes	multi select	
Physical factor	Char	Yes	multi select	
Man-made factor	Char	Yes	multi select	
Dominator factor	Char	Yes	single select	
Induced factor to relive	Char	Yes	multi select	
Present state	Char	Yes	single select	
Developing trend	Char	Yes	single select	
Death toll	Integer	Yes		person
House damage	single	Yes		room
Road damage	single	Yes		meter
Trend damage	single	Yes		meter
Other damage	char	No		
Direct loss	single	Yes		ten thousand RMB
Indirect loss	single	Yes		ten thousand RMB
Hazard type	char	No		
Influential range	char	No		
Loss	single	No		ten thousand RMB
Threaten population	integer	Yes		person
Threaten wealth	single	Yes		ten thousand RMB
Monitoring suggestion	char	Yes	multi select	
Prevention suggestion	char	Yes	multi select	
Plane drawing	char	No		
Section drawing	char	No		
Survey company	char	Yes		
Survey manager	char	Yes		
Fill in person	char	Yes		
Check person	char	Yes		
Filling date	char	Yes		
System version	char	Yes	●	
Data mask	char	Yes	●	
Save time	char	Yes	●	
Data file	char	Yes	●	
Collection system_ID	integer	Yes	●	

Table 2. Rock Fall Survey Data Structure Table

Field name	Data type	Required	Description	Unit
ID	char	Yes	●	
Project name	char	No		
Mapsheet name	char	No		
Mapsheet ID	char	No		
Name	char	Yes		
Field ID	char	Yes		
General ID	char	Yes		
Location	char	Yes		
Slope type	char	Yes	single select	
GPS longitude	single	Yes	●	degree
GPS latitude	single	Yes	●	degree
GPS altitude	single	Yes	●	meter
longitude	single	Yes		degree
latitude	single	Yes		degree
Top of slope	single	Yes		meter
Foot of slope	single	Yes		meter
Stratum epoch	char	Yes	single select	
Stratum lithology	char	Yes	multi select	
Stratum incline	Integer	Yes		degree
Stratum dip angle	integer	Yes		degree
Structure location	char	No		
Seismic intensity	char	Yes	single select	
Micro topography	char	Yes	single select	
Ground water type	char	Yes	multi select	
Annual rainfall	single	No		millimeter
Max day-rainfall	single	No		millimeter
Max hour-rainfall	single	No		millimeter
Flood level	single	No		meter
Low water level	single	No		meter
Location to river	char	Yes	multi select	
Land utilize	char	Yes	multi select	
Slope height	single	Yes		meter
Slope length	single	Yes		meter
Slope width	single	Yes		meter
Slope degree	integer	Yes		degree
Slope incline	integer	Yes		degree
Slope plane type	char	Yes	single select	
Rock structure type	char	Yes		
Thickness	single	Yes		meter
Cranny group number	char	Yes		
Size of block	char	Yes		meter
Slope structure type	char	Yes	single select	
Structural area type no.1	char	No		
Structural area incline no.1	integer	No		degree
Structural area dip angle no.1	integer	No		degree
Structural area length no.1	single	No		meter
Structural area internal no.1	single	No		meter
Structural area type no.1	char	No		
Structural area incline no.1	integer	No		degree
Structural area dip angle no.1	integer	No		degree
Structural area length no.2	single	No		meter
Structural area internal no.2	single	No		meter
Rotten zone depth	single	No		meter
Non-load cranny depth	single	No		meter
Soil name	char	No		
Density	char	No	single select	
Degree of denseness	char	No		
underside bedrock lithology	char	No	multi select	
underside bedrock incline	integer	No		degree
underside bedrock dip angle	integer	No		degree
Underside bedrock buried depth	single	No		meter
Ground water buried depth	single	No		meter
Out crop	char	No	multi select	
Supply type	char	No	multi select	
Deformation name no.1	char	No	single select	
Deformation location no.1	char	No		
Deformation feature no.1	char	No		
Deformation time no.1	char	No		
Deformation name no.2	char	No	single select	
Deformation location no.2	char	No		
Deformation feature no.2	char	No		
Deformation time no.2	char	No		
Unstable factor	char	Yes	multi select	
Stable degree	char	Yes	single select	
Changing trend	char	Yes	single select	
Death toll	single	Yes		person
House damage	single	Yes		room
Road damage	single	Yes		meter
Trend damage	single	Yes		meter
Other damage	char	No		
Direct loss	single	Yes		ten thousand RMB
Indirect loss	single	Yes		ten thousand RMB
Hazard type	char	No		
Influential range	char	No		
Loss	single	Yes		ten thousand RMB
Threaten population	single	Yes		person
Threaten wealth	single	Yes		ten thousand RMB
Monitoring suggestion	char	Yes	multi select	
Prevention suggestion	char	Yes	multi select	
Plane drawing	char	Yes		
Section drawing	char	Yes		
Survey company	char	Yes		
Survey manager	char	Yes		
Fill in person	char	Yes		
Check person	char	Yes		
Filling date	char	Yes		
System version	char	Yes	●	
Data mask	char	Yes	●	
Save time	char	Yes	●	
Data file	char	Yes	●	
Collection system_ID	integer	Yes	●	

The data check and quality evaluation methods result from the factor system of data quality. The data quality control software is developed for improving the accuracy and efficiency of data check.

5 CONCLUSIONS

Construction of the Geo-hazard Survey Information System is a complicated system engineering task, which is based on the geo-hazard survey data and applying information technology. The information technology relates to digital production technology, data quality control technology, spatial database technology, mass multi-mapsheet data organization and management technology, data share and publishing technology. The construction of the system is not a simple digital and software development, but also a huge innovational project utilizing information integrated technology. The achievement reflects systemic, professional, authority, reliability and superiority.