EARTHQUAKE DISASTER GIS AND SPATIAL-TEMPORAL PATTERN OF EARTHQUAKE DISASTERS IN CHINA

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ABSTRACT :

This paper summarizes the development of a Geographic Information System for managing and analyzing information on the effects of earthquakes in historical times of China. The extensive bibliography documenting the seismicity from B.C.3000 showed the need to proceed towards a type of data storage that would also allow management of the same data. Application of GIS techniques allowed us to insert, extract, handle and analyze the data for the zoning of seismic damage. The end-product consists of information layers such as maps of earthquake intensity, the expected damage, and hazard involved, as well as numerical tables associated to maps. The study was developed using ARCGIS9.2 software and is structured in thematic vectorial levels and rasters. The overlapping themes constitute a spatial data base, into which all information on the historical Seismicity of China, starting from B.C.3000, by means of archives and literature, are channeled. The damaged sites are located on a map, with all the information on the historical earthquake (death toll, number of collapsed houses, economic losses.) being associated to each site. The GIS is structured in such a way as to be able to be integrated with further georeferenced data and with other databases.Moreover,the system within the GIS initial processing offers a high level of analysis sophistication and integrates state-of-the-art information processing tools, which enable end-users to construct interpretative summaries, especially the spatial-temporal pattern of seismic hazard in China is conducted, it is thus able to provide support both for assess the damage, define its geographical distribution, identify the regions repeatedly affected by seismic events, quantify the level of seismicity and extend the assessment to other natural risks.

KEYWORDS: GIS, Historical seismicity, Earthquake hazard, China

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1. INTRODUCTION

Seismic Zoning can be used for raising risk awareness, especially among decision makers, and also for helping formulate and apply risk mitigation policies and measures, especially for predisaster planning and preparedness.However,the pertinent studies are rather complex and time-consuming mainly due to data collection if good-quality census data are not available.

The capacity of Geographic Information Systems to store and process data and images makes the use of such systems very valuable in the field of seismic zoning, because the latter is chiefly based on the processing of data regarding the damage produced by historical and present-day earthquakes as well as its distribution in space. We chose to construct a GIS on the basis of China's historical seismicity which, in terms of quantity and quality of the known data, can be used as an efficient tool for the creation of an integrated information system which permits a comparison of the data from different sources. The information on China's seismicity covers almost 5000 years, starting from B.C.3000, by means of historical bibliography. A cross-analysis of this data allows us to access the damage, define its geographical distribution, identify the areas repeatedly affected by seismic events, and quantify the level of seismicity in the area.

2. DOCUMENTATION FORMING THE BASIS OF THE GIS

The starting-point to construct a GIS on the historical seismicity of the China cities was the availability of two types of documentation: data from archives and from the literature. The study developed in two main directions: first, two relational databases were designed to contain in detail the historical seismic data since B.C. 3000, using published and unpublished sources, mainly from 'Historical Records' and 'History as a Mirror'; second, the available maps were acquired, a spatial database was create likewise to store and manage multi sources map data, which would be used as the basis for developing the study.

Through collecting materials of historical earthquake in China and materials of earthquake hazard and disaster up to data, two databases ,namely historical earthquake DB and earthquake hazard and disaster DB in China were established by comparing the materials from different sources ,mainly from 'Historical Records', 'History as a Mirror' and pertinent government disaster reports. Two databases include information such as location, time, magnitude, hazard and disaster of nearly 6000 earthquakes from B.C.3000 to 2008, and prepare comparatively complete data for proceeding research. The data gathered were grouped by locality; each locality may correspond to a road, a village, or a square, so that the damage data might be defined for each. This choice, due to the impossibility of locating individual buildings, proved very effective for delimiting the zones with different levels of damage under various geological conditions and thereby evaluates the effects of a future seismic event in China.

After we created two rational databases, we need to acquired choropleth maps and pertinent geological and tectonic map data, geographical map data etc., which can be used not only as the necessary basis for locality reference but also as a primary backcloth for rendering, displaying and exporting. These maps may originate from a variety of sources and formats, we have to employ GIS software, namely ARCGIS series tools like ArcMap or ArcCatalogue, to digitalize, transform and project these map data, with the aim of uniforming so as to facilitate further application.

3. THE PROJECT AND THE GIS STRUCTURE

Generally speaking, the GIS is often used as a "container" into which all the data acquired on the historical seismicity of China are channeled effectively. First of all, the GIS project almost entailed the acquisition of the numerical map data base of the whole area of China. These maps were an indispensable tool for localizing and representing data and to interrogate the actual data in order to construct interpretative summaries. The spatial database is the reference framework for all the data and information on the earthquake in historical times of

China, which concern the damage incurred at the various locations. Each location is a well-defined inhabited site and is identifiable as a set of several damaged buildings. The topographical map represents a useful reference point for the concurrent residential situation and hence of the clear identification of sites.

The data available, for the purpose of processing in the GIS, were digitalized and inserted into spreadsheets or tables. Each spreadsheet includes the data concerning the sites. With the spreadsheets or tables we performed initial processing that led, starting from the damage incurred by individual buildings, to the definition of damage at the site.

The methodology used in this study is presented in the flow diagram given in Figure 1.At first we collected and analyzed two main published documentations, 'Historical Records' and 'History as a Mirror', by which we outlined the whole historical time span, to be used as a time referenced coordinate frame in order to register

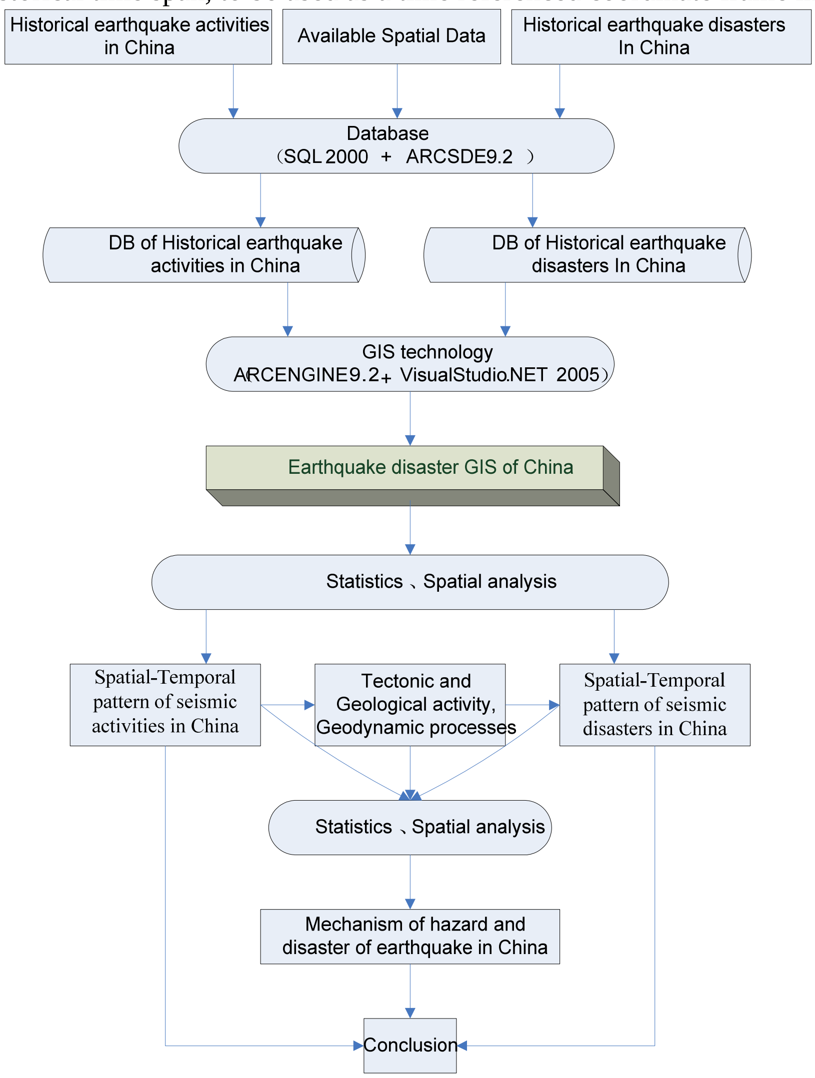

Figure 1.Flowchart for the methodology

every historical earthquake record as possible as we can, each record is composed of its time, position, and its damage description in detail, then we enrich these records by means of referring to other published or unpublished sources like literature or internet. Thus two rational databases were created to keep historical seismic activities and historical earthquake hazard and disaster separately; Secondly, the spatial database mentioned above was also created to provide a background for reference and view geographically referenced data; And then a GIS using ArcEngine SDK was developed for processing, managing and representing the historical seismic data,moreover,the system within the GIS initial processing offers a high level of analysis sophistication and integrates state-of-the-art information processing tools, which enable us to construct interpretative summaries, it is thus able to provide support both for assess the damage, define its geographical distribution, identify the regions repeatedly affected by seismic events, quantify the level of seismicity,and most of all commence a research on spatial-temporal pattern of seismic hazard in China; Finally, some Seismic Zoning maps or tables would be made used for raising risk awareness and also for helping formulate and apply risk mitigation policies and measures, especially for predisaster planning and preparedness.

4. DATA CONSULTATION AND DISPLAY

The main advantages of GIS software consist in its simplicity of use and the immediacy of access to information. The data concerning each site may be displayed straightforwardly by using the windows that GIS software provides. It is thus possible to interrogate the points by user operations like a single click or a SQL search on the map, which represent the individual sites, so as to obtain a zoom window that supplies information about damage for set locations. Likewise, each site may also be identified by the tables, selecting it and viewing it automatically in the map. The data analysis by the GIS within the initial processing allows the production of appropriate thematic representations for the various requirements of spatial analysis.

The damaged sites were digitalized on the numerical map with the insertion of points, each point constituting and representing a damaged location. Using an identification code, the data on the damage were connected to the individual points, displaying a one-to-one correspondence on the map. Connecting the data with the map allows within the GIS initial processing producing the thematic maps. In the specific case, connection of the points to the data on damage to some historical places whose names no longer use today would encounter a matching issue, when this issue happened, an address matching work would be necessary before we step next.

The structure and workings of the GIS allow many automatic operations to be performed for the integrated representation of various types of data, such as the overlay of several thematic maps, namely the geological and tectonic maps and the DEM, which can show the contribution of geological and tectonic structures to earthquake intensity. The comparison between geology and tectonics and the earthquake intensity distribution is shown in Figure 2.

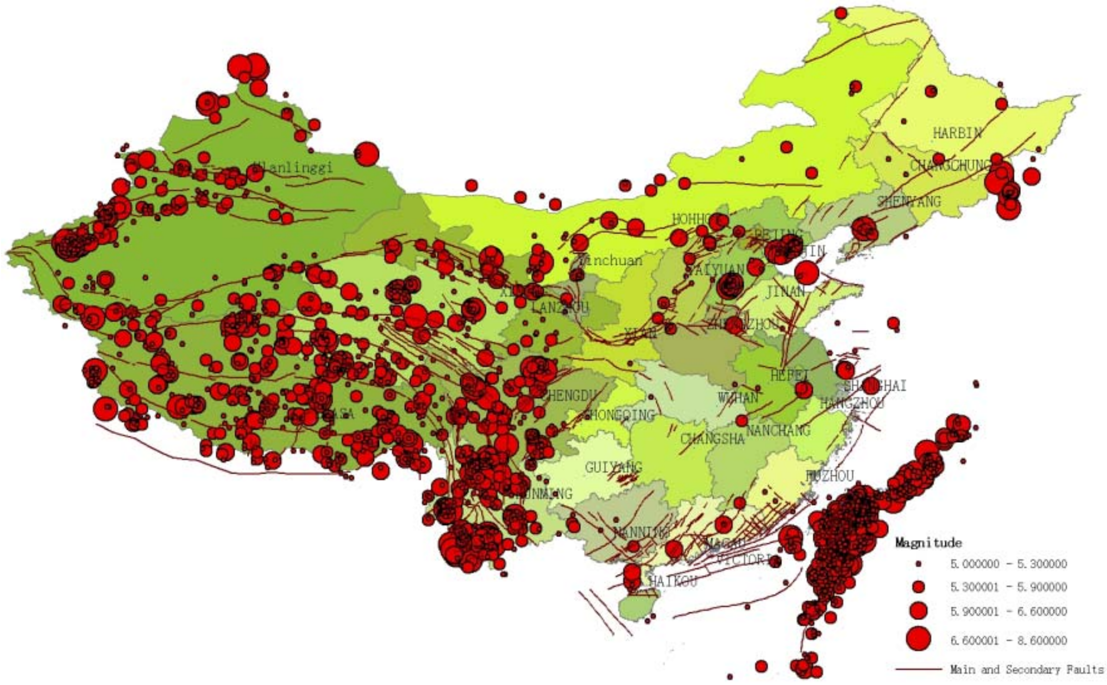

Figure 2. Historical Earthquake intensity distribution and Main and Secondary Faults

Besides the overlay of the map of earthquake intensity with other available maps, the GIS allow us to perform other data processing operations, which are useful for hazard assessment. Using the "map overlay" of the various thematic fields we obtain a sufficiently complete picture to identify the area in the case of future seismic events assuming sources located as given in Figure 3. For example, we may identify homogeneous areas in terms of damage by means of fitting procedures, generating a grid with points at variable distances, thereby defining the various levels of intensity throughout the China.

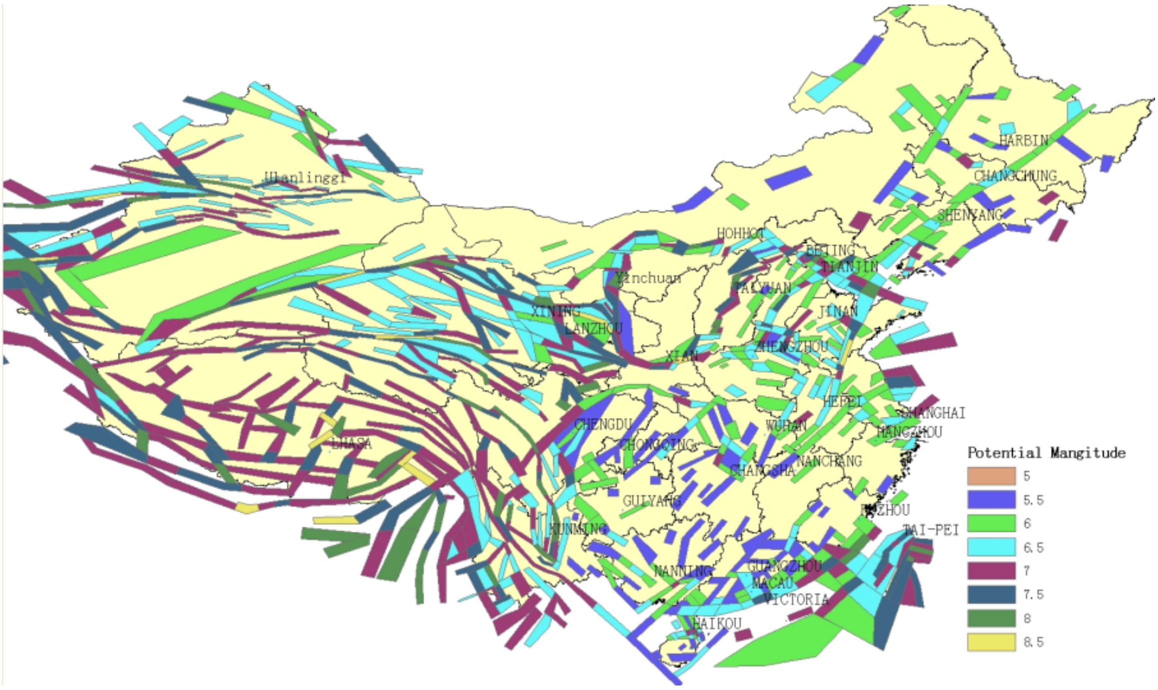

Figure 3.Potential Seismic sources in China

5. RESULTS AND DISCUSSION

Combining map of epicenter distribution, earthquake statistics data in mainland and map of annual earthquake variation, the characteristic of high frequency, big intensity, broad and asymmetrical distribution in space and time of earthquake activities in China is concluded. In the research of magnitude information, along with the attenuation of energy release, earthquake distribution in China expands to different direction according to different density and range. In the study of era information, spatial pattern of earthquake changed from one center (North China) to two centers (North China and Southwest China), differences between the north and the south to differences between the east and the west. According to the historical earthquakes statistics, August reached the maximum frequency both in its total number of earthquake and in its magnitude, thus, August would be the key month of mitigation.

Contrasting with the spatial-temporal pattern of earthquake activities, which is strong in the west and weak in the east as concluded above, the spatial-temporal pattern of earthquake hazard and disaster is strong in the east and weak in the west. This showed that the east is easier than the west in the formation of earthquake disaster and in the disaster loss, and the result is that vulnerability of earthquake disaster of the east mainland is more vulnerable than that of west. Analysis of map of annual earthquake variation shows that death population of earthquake takes on decreasing trend but economic loss increasing. Analysis of map spatial pattern of disaster degree shows that many earthquake disaster events took place in North China and Southwest and earthquake of all levels were included.Earthquak disaster events were frequent in the east of Tibet Plateau but earthquakes with big loss were few. Earthquake disaster events were few in East China and Northeast but big loss occurred once earthquake took place. Based on the comparison of disaster degree for the east and the west of mainland, conclusion can be drawn that the leading factor of earthquake disaster in the west is the hazard danger, and in the east is the vulnerability of the environment.

Identical to other researchers , the analysis results described above showed some similarity, this paper does not claim to introduce new concepts or develop new methodology, on the contrary, its purpose is to summarize the development of a GIS for managing and analyzing information on the effects of earthquakes in historical times of China, in this way, a more in-depth study such as research on spatial-temporal pattern of seismic hazard in China or further complicated data mining can be conducted more conveniently.

6. CONCLUSION

GIS have proved to be useful tools for analyzing natural risks such as those linked to earthquakes which involve complex interactions with the natural and man-made environment. The application of GIS and spatial modeling in natural hazard risk management is an emerging research sector and the ability to provide a spatial and physical context for risk is critically important for risk reduction.

In this study we showed how a GIS might be employed to produce maps of potential damage to be used in planning an area at risk. However, this result may only be obtained with the use of appropriate algorithms of spatial analysis within the GIS, which take account, in the case of earthquakes, of the seismic source, the law of energy propagation, the geological, morphological and tectonic characteristics of the sites and information concerning previously recorded damage. In addition the GIS could be continually updated with new data or integrated with other GIS databases, showing its simplicity of use and the immediacy of access to information, which would facilitate further application.

Using GIS developed above, we analyzed the spatial-temporal pattern of seismic hazard in China both by joint analysis of historical seismicity, geology and the geodynamic processes which have affected China often, and by considerable pertinent mathematical statistics. We can not rule out a renewal of seismic activity in the area connected both to tectonic and geological activity, this raises the problem of mitigation of seismic risk, it is therefore necessary to conduct a more in-depth study of the areas where have repeatedly experienced seismic events, together with an analysis of geological structure, so as to define the seismogenetic sources and mechanisms that govern seismic energy release processes and identity the areas most exposed to damage, which can be used for raising seismic risk awareness and for helping formulate and apply risk mitigation policies and measures, especially for predisaster planning and preparedness.

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