An Integrated Geodisaster Management System for China

— Experiences from Western Countries

YUAN Guohua

Sept, 2001

An Integrated Geodisaster Management System for China

by

YUAN Guohua

IFA Report submitted to the International Institute for Aerospace Survey and Earth Sciences in partial fulfilment of the requirements for the degree of Professional Master in Natural Hazards Study

Degree Assessment Board

Supervisors: Prof. Dr. **John van Genderen** and Asso. Prof. Dr. **Cees van Westen**
Other members DAB: **B. Maathuis**, **J.B. de Smeth**

ITC

INTERNATIONAL INSTITUTE FOR AEROSPACE SURVEY AND EARTH SCIENCES
ENSCHEDE, THE NETHERLANDS

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1. Introduction

China is located at the western margin of the Pacific Ocean, and is bounded by Pacific, Euro-Asian and Indian Plates. The geological settings and geographical conditions dominate the varieties of natural resources and also disasters there. As a giant fast growing economy, China is facing various resources, environmental and disaster problems. In managing the quick industrialising economy, the integration of Western experiences in resource and disaster management is always meaningful and helpful.

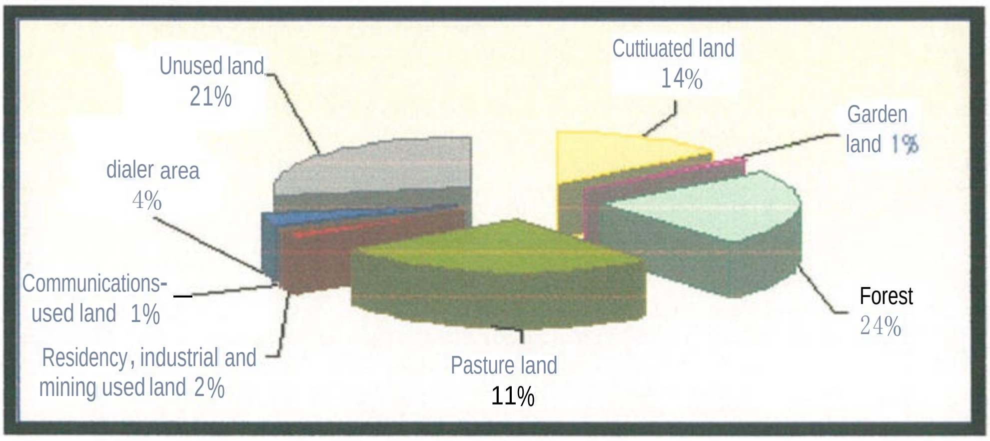
1.1. Managing the Land and Resources for the Fast Developing Economy

1.1.1. China Can Feed Itself

With a huge and still growing population and limited land and other resources, “Can China feed itself?^ has been the world focus. In 1996, Leister Brown of the Worldwatch Institute issued a report “Can China feed itself?” raised worldwide arguments. So what’s the situation of China’s land, especially the cultivated land?
According to a national survey of land utilization situation in 1996, the following are the areas of major land categories respectively in China[01]:

Cultivated Land: 130.0392 million hectares (1.951 billion acres);
Garden Land: 10.0238 million hectares (150 million acres);
Forest Land: 227.6087 million hectares (3.414 billion acres):
Pasture Land: 266.0648 million hectares (3.991 billion acres);
Residential, Industrial and mining-Used Land: 24.0753 million hectares (361 million acres);
Communications-Used Land: 5.4677 million hectares (82 million acres);
The rest are water area and unused land, see Figure 01.

Figure 01 Structure of China’ s Land Use (Source: [01])

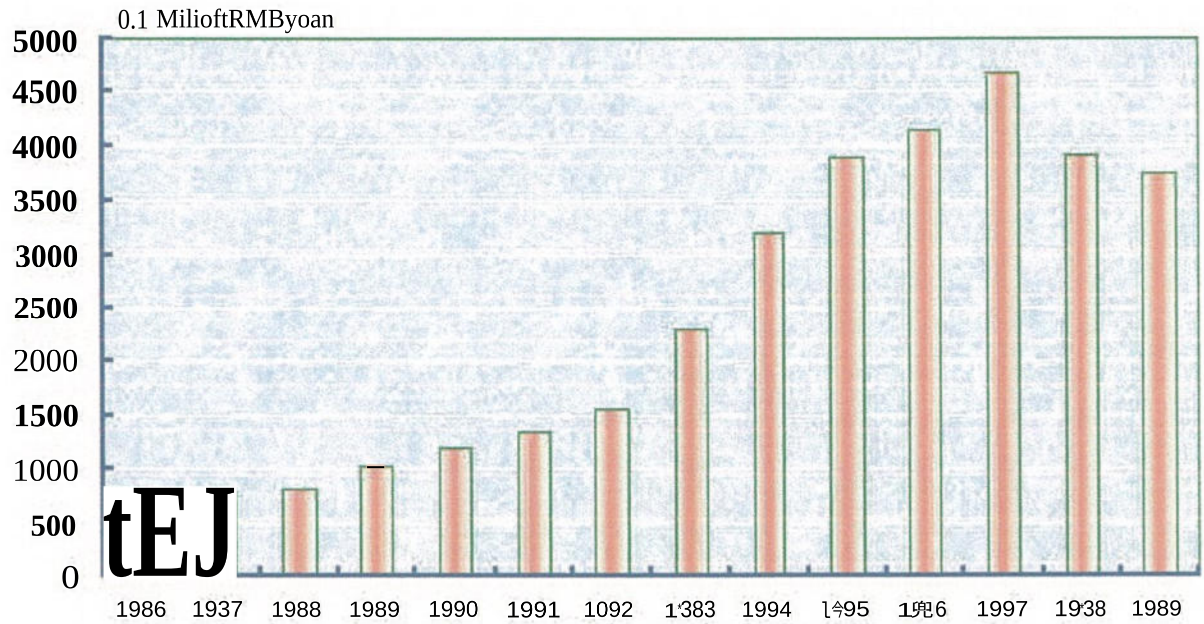


Actually China still has potential land for cultivation. It is predicted China will reach its highest population of 1.5 billion in 2030, then the population will stop to grow. With the inprovements of cultivation and technological progress, China can manage its population with enough food [02]. China's annual GDP grew at 8.3% in 1996-2000, and expected to grow at 7-8% annually in 2001-2010. With the development of the economy, China will have more resources to secure safety food supply.

1.1.2. Mineral Resources and Production

China is very rich in mineral resources and is a huge mining country. Now about 175 types of minerals have been discovered, with more than 200,000 deposits and mineral occurrences, in which 20,000 have detailed exploration. After over 50 years of construction, there are about 8,000 state-run mines out of more than 100,000 mines in total. Accompanying the continuous rapid industrialisation process, China's mineral industry played, is playing and will play an important role in the nation's economy. It's estimated that the mineral industry has provided 95% of primary energy, about 80% of industrial raw materials, above 70% of agricultural producer's goods, 30% of irrigating water and one third of drinking water for its economy[03]. The output of China's mining industry is shown in Figure 02.

Figure 02 Outputs of China's Mining Industry in Recent Years (Source: 03)

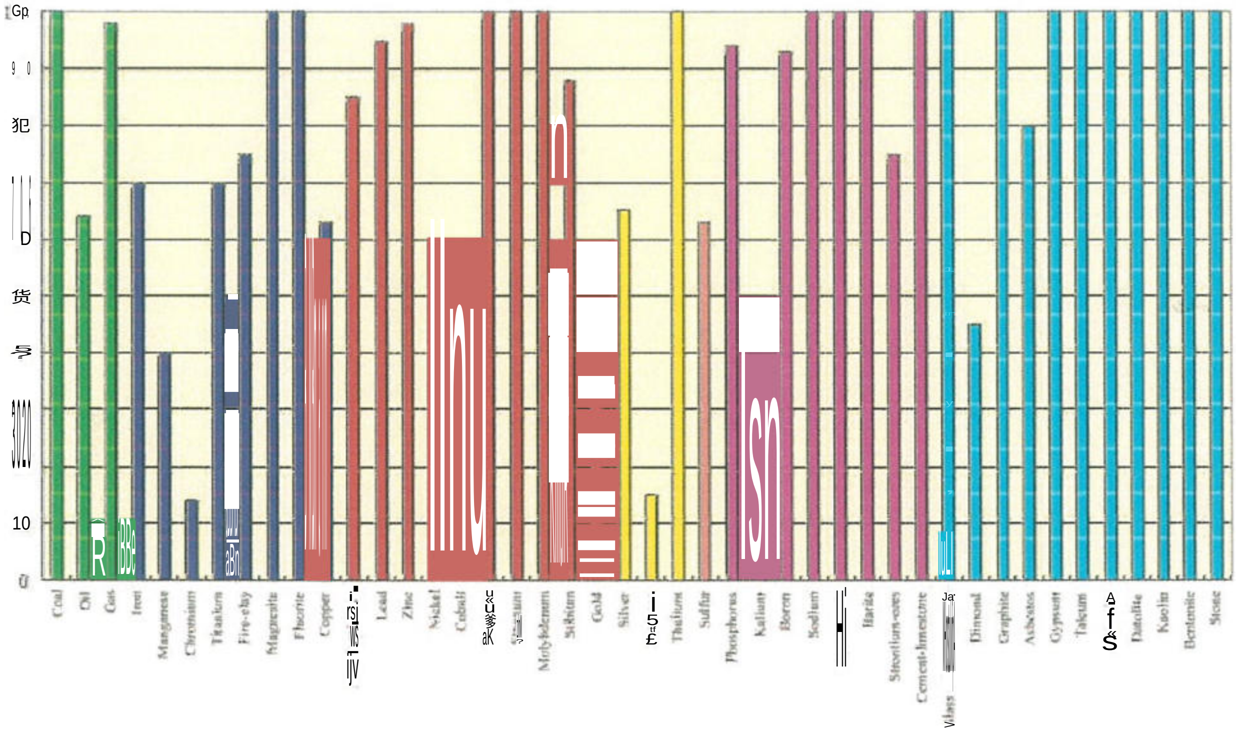


Also it is predicted that 21 essential minerals out of 45 commonly used will run short of reserves in the year 2010 (see Figure 03). Now the Chinese Authorities are taking action to deal with the problems concerned.

1.1.3. Projects Being Done Under Ministry of Land and Resources

The Ministry of Land and Resources, MLR is trying to formulate an integrated resources management system including mineral resources, land, ocean resources etc, by carrying out the New Round Land and Resources Survey nationwide, using advanced technologies such as RS and GIS to fulfill different scales surveying in a corrqprehensive way to meet the growing demands of economic growth and social progress, as well as to formulate an Outline for National Mineral Resources Planning, and trying to fulfill this at a regional level. This work is still underway, without much practical experience, and enhancement should be made in detail. Investigations of mining environments in pilot study Provinces are being carried out to figure out the present situation of and to lay out the necessary regulations governing mine environment, as it's becoming a more and more severe problem affecting the sustainable development of mineral industry. Effort is also being made by MLR to build its own mineral availability system.

Figure 03 Guarantee Degrees of Domestic Minerals to China's National Economy in 2010



(Source: Provided by Chinese Institute of Information on Land and Resources, see 03)

Continuous concentration has always been paid on the reforming and adjustment of present policies and regulations in the areas as statute implementing the mineral resources law, reserve management, resource tax and fee system reform, and policies attracting foreign investment in mineral industry etc. In the coming years, the following five aspects will be addressed.

First of all, to enhance the land administration work, especially to protect the cultivated lands, and realize its dynamic balance in gross.

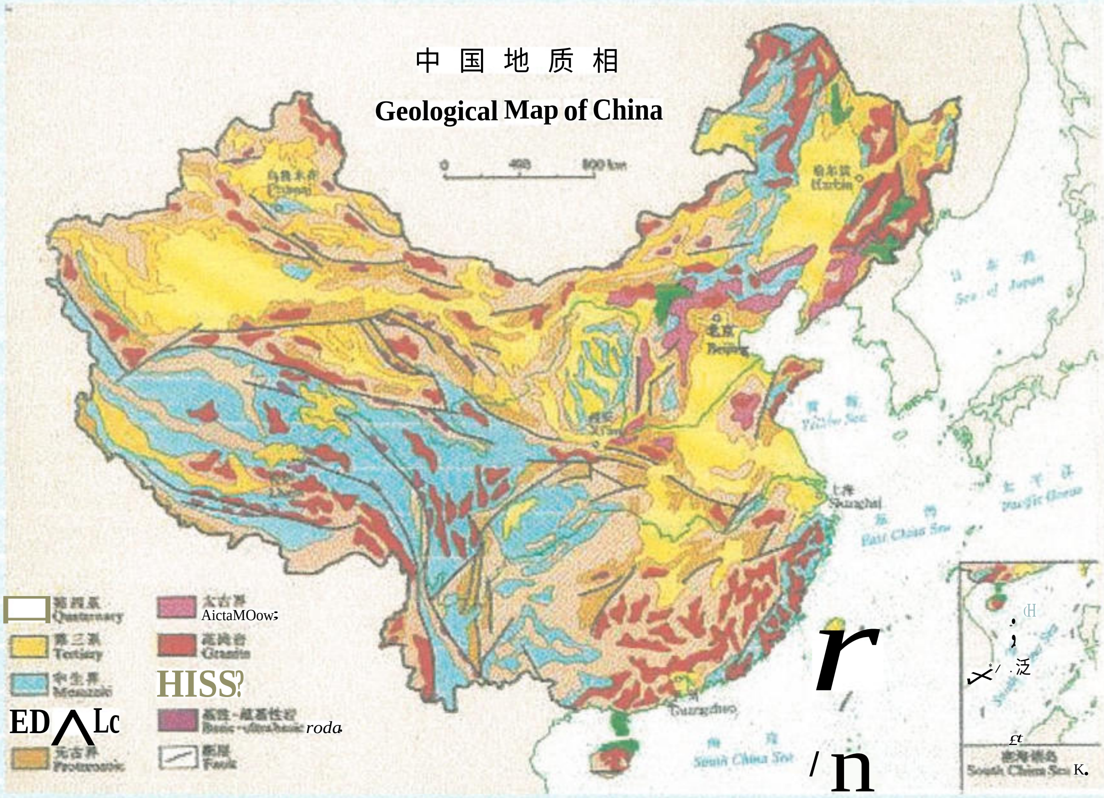
Secondly, to enhance investigation, evaluation and planning of land resources, so as to make greater contribution to the development of the national economy. The new national survey of land and resources is under way. The basic, public-welfare, and strategic explorations will also be strengthened, in order to increase the proven reserves. Especially we will make much more explorations in Western China, in order to find out more groundwater resources to meet local demands. Meanwhile, exploration, supervision and prevention of geological disasters must also be strengthened, trying to avoid or mitigate corresponding losses thereof.

Thirdly, to enhance the information system construction and make the information services accessible.

Fourthly, to deepen reforms step by step so as to set up a new system or mechanism for the management of land and resources.

Finally, to improve our law system, administer legally, and put the land management in order fundamentally.

BOX 01 China's Geological Setting and Mineral Resources in Western Region (Figure 04)



(Source: http://ghviiaD.tripod.com/rcso/cngeologv.html. Table 01 is based on Mineral Reserve Statistics 1998)

Table 01 Western and Central China's Main Mineral Reserve Shares (1998)

Minerals	Units	China	Central	West	Central & Western
Oil	10^4 t	100	42.57	**20.95**	63.52
Natural Gas	10^8 m^3	100	7.58	**64.59**	62.17
Coal	Kt	100	56.05	**38.75**	94.80
Iron Ore	OreKt	100	28.55	**23.76**	52.32
Manganese	OreKt	100	23.48	**67.11**	90.59
Chromite	OreKt	100	17.83	**72.63**	90.46
Copper	Cut	100	48.61	**43.23**	91.84
Lead	Pbt	100	29.84	**46.53**	76.37
Zinc	Zn t	100	29.91	**50.53**	80.44
Aluminium	OreKt	100	58.86	**37.06**	95.92
Nickel	Nit	100	9.67	**89.48**	99.15
Tin	Sn t	100	23.62	**64.89**	88.51
Gold	Au t	100	35.7	**27.58**	63.28
Silver	Agt	100	43.36	**33.86**	77.22
Cement Lst	OreKt	100	30.37	**36.37**	66.74
Potassium	KCLKt	100		**98.45**	98.45
Phosphorite	OreKt	100	33.18	**56.75**	89.93
Area	MKm^2	9.60	2.842	**5.424**	8.266

1.2. Managing Geodisasters for a Better Development

The final purposes of disaster research and environmental studies are to protect development results, improve development environment and raise development quality!

China is prone to many kinds of geological hazards due to its geological settings and geographical background, and also unreasonable exploitations. In the past decades, damages and losses due to natural and man-induced disasters have increased definitely; the annual average damage due to geological disasters is about 27 billion *yuan* RMB[01]. Efforts for disaster reduction have also achieved countable effects. In recent years, especially from the last decade, the international communities, from UN to regional Governments to NGOs at every level have paid great attention to disaster problems in the right way, and resulted in a more thorough understanding of sustainable development. Especially in the European Community, technological progress and institutional construction have resulted in disaster reduction being integrated into the socio-economical system, and that builds a sound cultural environment for disaster reduction. For example, the under- construction FORMIDABLE (Friendly Operational Risk Management through Interoperable Decision Aid Based on Local Events) and DECIDE (Earth Observation Technologies for DECIsion support Demonstration) projects [04]. But in most of the developing countries, a disaster is always taken as just a "case problem"; great efforts both technological and institutional should be made to deal with the disaster problem.

China suffers frequently from geological hazards, and these hazards are of various categories, wide distribution and extensive influences.

China has totally more than 3,000 major avalanches, 2000 landslides, 2000 debris flows, and more than tens of thousands medium-small sized avalanches, landslides and debris flows. In China, more than 400 counties and 10,000 villages are threatened, among which, above 60 cities and towns are frequently intruded by landslides and avalanches, more than 50 cities and towns are frequently intruded by debris flows [011.

The following are places seriously threatened by geological hazards: Beijing, Hebei, Jiangxi, Hubei, Hunan, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi and Gansu provinces.

In 1998, about 180,000 geological hazards such as avalanches, landslides and debris flows in different sizes occurred in China, among which, 477 ones were in large size, resulting in 1,573 people dead, more than 10,000 people injured, 500,000 houses destroyed, with 27 billion *yuan* worth of direct economic losses together.

Meanwhile, there were more than 1,500 Km^2 of collapses, among which, there were 2841 karst collapses, with a total area of 332 Km^2, mainly located in Liaoning, Hebei, Jiangxi, Hubei, Sichuan, Guizhou, Yunnan, Guangdong and Guangxi provinces, etc.; and, there were more than 180 mining collapses, with a total area of 1150 Km^2, mainly located in Heilongjiang, Shanxi, Anhui, Jiangxi and Shandong provinces, etc.

On the other hand, land subsidence occurred in 46 cities and counties of Shanghai, Tianjin, Jiangsu, Zhejiang and Shaanxi provinces (autonomous regions and municipalities directly under the Central Government), with a total subsidence area of 48.7 thousand Km^2; and 434 ground fissures existed in 17 provinces (autonomous regions and municipalities directly un[redacted]r the Central Government), such as Shaanxi, Hebei and Shandong, with a total length of 346.78 Km .

1.3. How Can the Western Experiences be Adapted and Integrated into the Chinese Management System

As China is about to enter the WTO and fulfilling a more open policy toward resource and disaster management areas, a more effective, internationally recognized and systematical management framework (including technical, institutional and legislative aspects) will be formulated later by the Chinese Authorities. In this process, how can the Western experiences be adapted and integrated into the Chinese system?

This IFA investigation tries to lay out an outline for China's (geological) disaster management from European and other regimes using GIS and multi-criterion analysis (MCA) techniques, based on our under-developing integrated disaster assessment system. More attention will be paid to disaster management, as the flowchart in next chapter shows.

2. Objectives and Methodology

There are so many different geodisasters with various magnitudes and emergent conditions in China. As a developing country, the Governments at all levels do not have enough resources to cope all the disasters. So in the past two decades, the Chinese Authority has been trying to build an effective geo-disaster management system focusing on an integrated geodisaster assessment system[06]. The following questions are covered in the system.

▲ What's the situation of a certain disaster or disasters in one specific region? The geological settings of the disaster and other factors affecting the disaster, evolution history, scale, magnitude and classification, probability and distribution, disaster forecasting etc are discussed.

▲ The response of the affected socio-economical system to the specific disaster, that is vulnerability study.

▲ What are the practical and expected damages by the specific disaster? What's the influence of the disaster to the socio-economical system?

▲ If measures have to be taken in coping with the disaster, for different disaster mitigation scenarios, what are the benefit/cost relationships?

▲ For Governments at different levels, what are the possible final solutions for the disaster problem (Multi-Criterion Assessment MCA for a Decision Support System DSS)?

In the system integration, modern techniques like database, remote sensing RS, geographic information system GIS and MCA are used.

The IFA (individual final assignment) study tries to integrate and enhance the following three aspects into the system to seek the reasonable solution for a specific disaster management problem involving Western experiences, based on a comparison study between China and the Western countries.

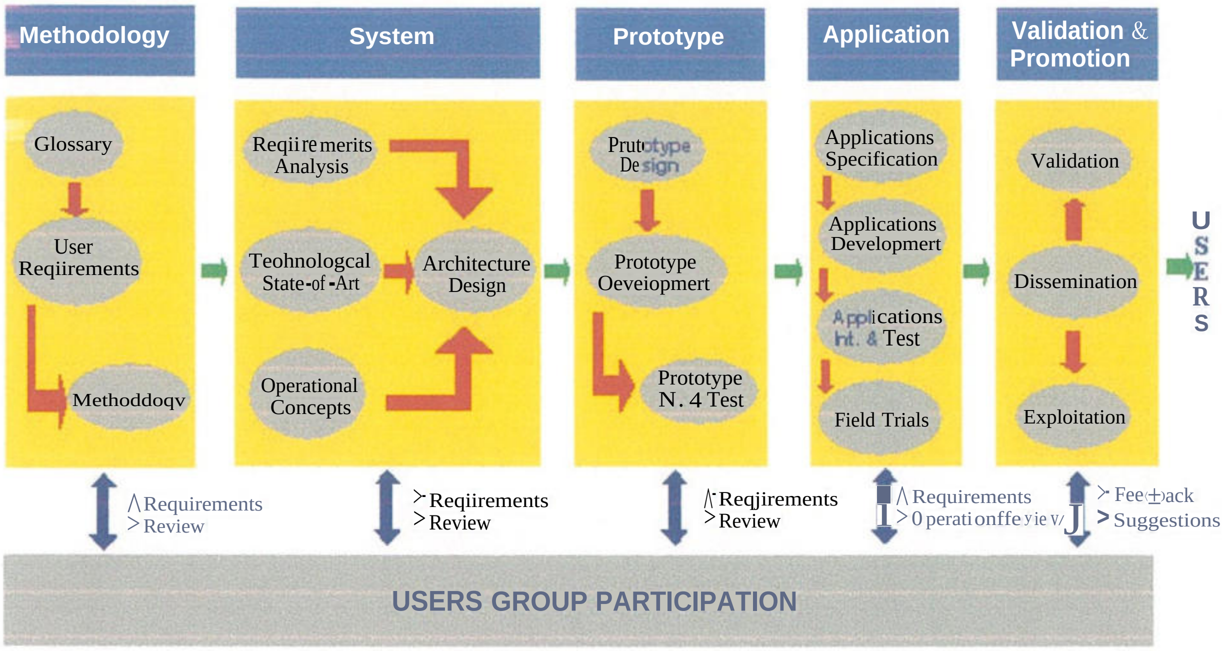
i. technological aspect;
ii. institutional aspect;
iii. legislative aspect.

2.1. What are the experiences of Western countries in natural disaster management?

Technologically, GS and GIS are now popularly used in disaster management [07] worldwide, especially GIS in coping with spatial disaster problems[08]. In EU, Earth Observation EO for hazard assessment has undergone for years [09], and now integrated global observing strategies for geological hazards theme is in process [10]. For disasters database construction, the Italian (landslide, flood) experience may be taken as an example (see http://wwwdb.gndci.pg.cnr.it). Numerical modeling is always used in dealing with the mechanism of one specific hazard [11]. For disaster management, DSS is more and more integrated into recent research projects, especially in EU countries, like FORFAIT (see http://ramses.esrin.esa.it/main.html), DeciDe (Earth Observation Technologies for Decision Support Demonstration, see http://www.lamma.rete.toscana.it) and FORMIDABLE [04].

In these projects, institutional problems are also included, Figure 05.

Figure 05 FORMIDABLE logic (Source: 04)



Legislative issues seem more complicated. Here more attention will be paid on the US emergency and the disaster management governed by the Robert T. Stafford Disaster Assistance And Emergency Relief Act. The newly issued landslide strategy by USGS (United States Geological Survey) is a nice example. For EU countries, attention will be paid on regulations, laws and policies governing emergency and risk management

2.2. Flowchart and Methodology Consideration

The proposed research approach adopted for this IFA is:

Internet searching + reference indexing;

Investigation (discussions with related professionals in various European countries);

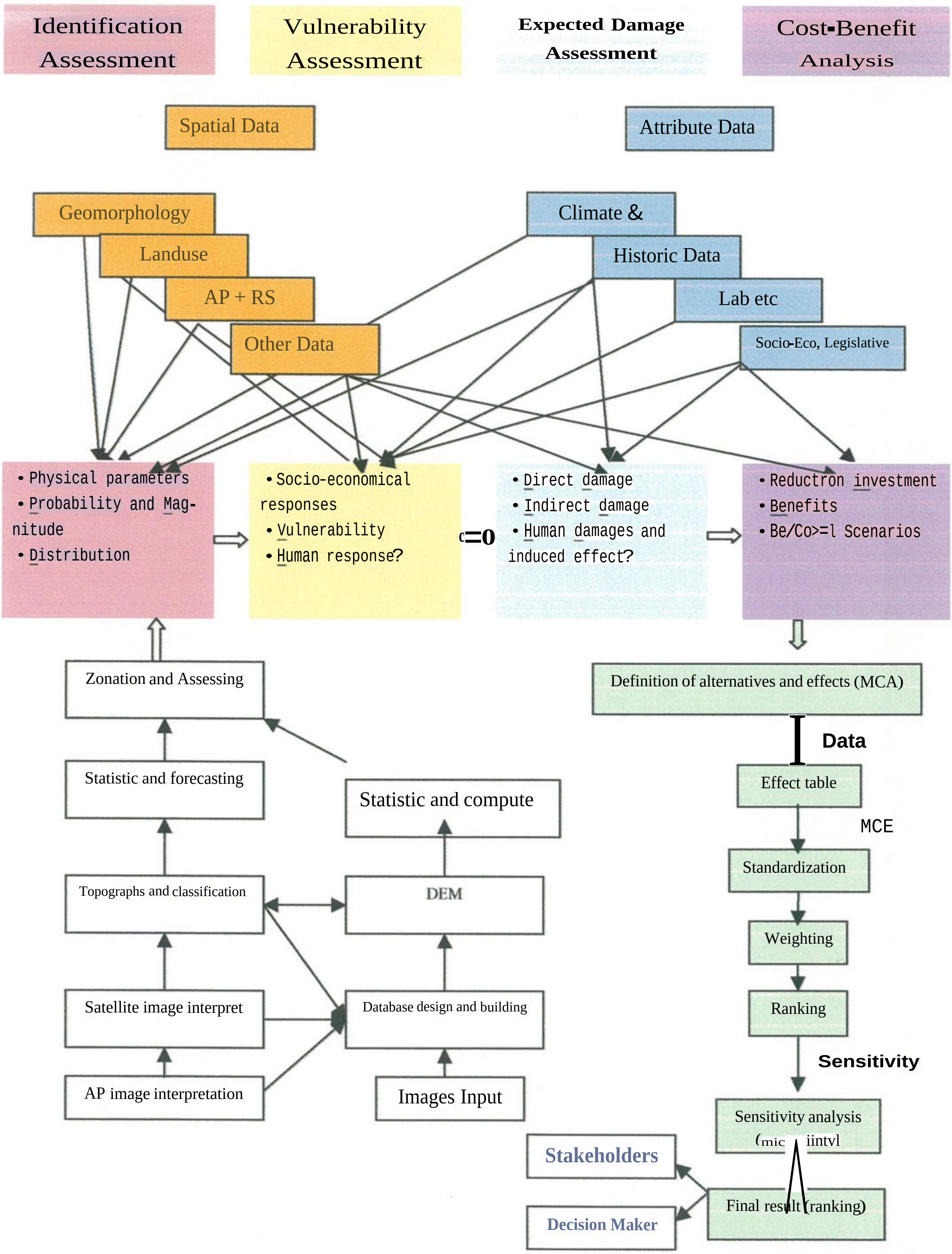
Data processing + computing + model building and integration (for the integrated system, not conducted in here).

For the designing of the system, in addition to the above, aerial photos and satellite images will be used, therefor GIS is necessary and will be used in processing the first three stages. The general flowchart shown in Figure 06.

2.3. The Design of A Proposed Scheme for China's Geodisaster Management

This study tries to build the frame of an integrated assessment system, especially based on the present situation of China and other developing countries. The potential users may include authorities at different levels, communities, NGOs and researchers of disaster related, planning and development focused. The study (disaster focused) characterized by focusing on forming a decision-support system,

Figure 06 General Flowchart of the Integrated Disaster Assessment System



assessment, vulnerability assessment, expected damage assessment and disaster reduction cost-benefit analysis [121, finally MCA for the solution of a specific disaster event.
The system is also suitable for dealing with regional disaster clusters, and thus makes it an important and indispensable tool for regional development planning.
Following is the main parts of the system developed in assessing China's ground fissure disaster [131.

2.3.1. Identification Analysis

Table 02 Factors for Ground Fissure Assessment [13]

Items	Contents
Classification	See table 03
Database	
Spatial Distribution	
Temporal Evolution	
Fatalness Indexes	See table 04
Fatalness Distribution	

Table 03 The Classification of Ground Fissure [13]

	Continuous Surface Crop Length (Km)		
	Λ1		<1
Surface Influence Wideth (m)	>10	VL (Very Large)	M
	10 - 3	L (Large)	
	3 - 1	M (Middle)	S
	<1	S (Small)	

Table 04 Classification of Ground Fissure Fatalness Indexes [13]

Grade	**Index**	**Features**			
		Tectonics (quake, fault etc)	**Extraction (mineral, water etc)**	**Surface Water (rainstorm etc)**	**Remark**
HA	9	Active fault; Quake trigger	Asymmetric depression	Heavy rainstorm	Other triggers
HB	7	Upper part of fault	Asymmetric depression	Heavy rainstorm	
HC	**5**	Away from fault crop	Central depression	Heavy rain	
HD	3	Away over half the length of fault	Depression center	Intermittent Heavy Rain	
HE	1	Far from fault; or without fault crop but with active tectonics	Depression can be seen	Intermittent rain	

2.3.2. Vulnerability Analysis

Table 05 Items and Contents for Vulnerability Assessment [13]

Items	Contents
Structure (Material) Vul.	
Economical Vul.	
Social Vul.	
Damage Rate	See table 06
Vulnerability Indexes	
Vulnerability Distribution	

Table 06 Damage Rate of Ground Fissure to A Structure* [13]

Damage Condition (%)			Structure Condition
Degree	**Damage Rate**	**Maintenance Cost/ Construction (%)**	
VG-very gentle	<5	<10 **(?)**	Basement cracked and extend to wall
G-gentle	5 - 20	<30 (?)	Wall or seam cracked, less components damaged
M-middle	20 - 50	<60 (?)	Crack extended, lots components damaged
H-heavy	50 - 75	<80 (?)	Most components damaged
VH	>75		Bid damaged, floor collapsed and abandoned

* (Based on 3-5-storey brick-cement bid)

2.3.3. Damage Assessment

Damage assessment is conducted in spot (specific disaster) assessment, local assessment and regional (and national) assessment separately. Each assessment is calculated by practical damage assessment and annual expected damage assessment separately. Methodologically, this process is somewhat like the FEMA developed methods [14].

2.3.4. Disaster Reduction Efficiency Assessment

The input in disaster reduction is the same as that in other socio-economic activities, but the effect of input ("output") differs greatly. Common socio-economic inputs always produce certain increments of social labour effects—the benefits of inputs. The inputs in disaster reduction do not produce this increment of social labour. However, the effect—the reduced loss RDL is certain and practical. So the benefit of disaster reduction is shown in comparison.

The input in disaster reduction is a preservative input. That is to input some money, preserve certain property; if no input, then this certain property may be destroyed by the disaster.

Items	Practical Damage Assessment (Annual)	Expected Damage Assessment (Annual)	Remarks
Spot Assessment	*1. Land damage DEO* DEO=Pf*Re*Se*Pe *2. Structure Damage DBO* DBO=Pf*Rb*Sb*Pb *3. Property damage DPO* DPO=Pf*Rp*Vp *4. Total damage DTO* DT0=DE0+DB0+DP0	*1. Land damage DEI* DEl=Pf*Re*Se*Pel *2. Structure Damage DB1* DBl=Pf*Rb*Sb*Pbl *3. Property damage DPI* DPl=Pf*Rp*Vpl *4. Total damage DTO* DT1=DE1+DB1+DP1 *5. Accumulated damage QD* (sum up each year with discount) QDn=SDTl	Pf – the probability Re, Rb, Rp –the damage rate of ground fissure to land, structure and property Se,Sb - the damaged area of land and structure Vp - total value of property
Local and regional assessments are similar to spot assessment.			

In disaster reduction investment, the time value of a fund is not shown properly. In common projects, the retrieving period (repaying years) of investment is the years needed for the net revenue to make up all the inputs (fixed and flexible). If the repaying time is Pt, cash flows out is CO, and cash flows in is Cl, then we have:

$$\sum_{t=1}^{Pt} (Cl-CO)_t = 0$$

In disaster reduction investment, Cl is not certain. If we take the reduced loss RDL as the cash flow in, we can construct the repaying period Pt of disaster reduction as:

$$\sum_{t=1}^{Pt} (RDL-CO)_t = 0$$

In the investment for disaster reduction, the scale is always determined by the different probability level (as a flood happened in 50 years). So in the evaluation, the relations between risk level and repaying period should be confirmed.

Economic benefit cost ratio B/C

Ratio of the disaster reduction benefit to the total cost in the counting period. The ratio should be ≥1, and the larger, the benefit better.

For a big disaster mitigation engineering project, EIRR and ENPV are used to evaluate the possible efficiency [10].

3. China's Geodisaster Management

3.1. China's Main Geodisasters

China is prone to nearly every kind of geological disasters except active volcanoes, and the management system differs from that of other countries.

3.1.1. Main Geological Disaster Types and Distribution

China has finished 1: 200,000 hydrogeological and engineering geological mapping in the past five decades. 25 Provinces (Autonomous Regions and Cities) have finished 1: 500,000 environmental geology investigations. All these works and other researches lay a basic foundation for the understanding of the background, causes, occurrences and development of different kinds of geodisasters nationwide. China's geological disasters can be divided into 10 groups and 31 types.

A. **Earthquake**: natural and man-induced earthquakes
B. **Displacement** (soil and rock): rockfall (avalanche), landslide and debris flow
C. **Ground Distortion**: land collapse, subsidence and ground fissure
D. **Land Degradation**: soil erosion, desertification, salination, cold (water quenched) field
E. **Oceanic Dynamic Disasters**: sea-level rising, sea water intrusion (aggression), bank erosion and harbor filling up
F. **Mine Disasters**: tunnel water bursting (seepage), coal fire, gas bursting and explosion, and rock blasting
G. **Special Soil Disasters**: damp-collapsed soil, swelling soil, silt soft soil, frozen earth, red earth
H. **Geochemical**: endemic diseases
I. **Groundwater Variation**: change of groundwater level, contamination
J. **River and Lake Disasters**: filling up, bank collapse and leakage

From the process causing damages, the above disasters are classified into four classes:

Class Ⅰ: directly destroy any establishment and installations, like earthquake, landslide, subsidence and tunnel water bursting etc, table 08.

Class Ⅱ: mainly cause the decrease (loss) of social production, like land salification and cold field.

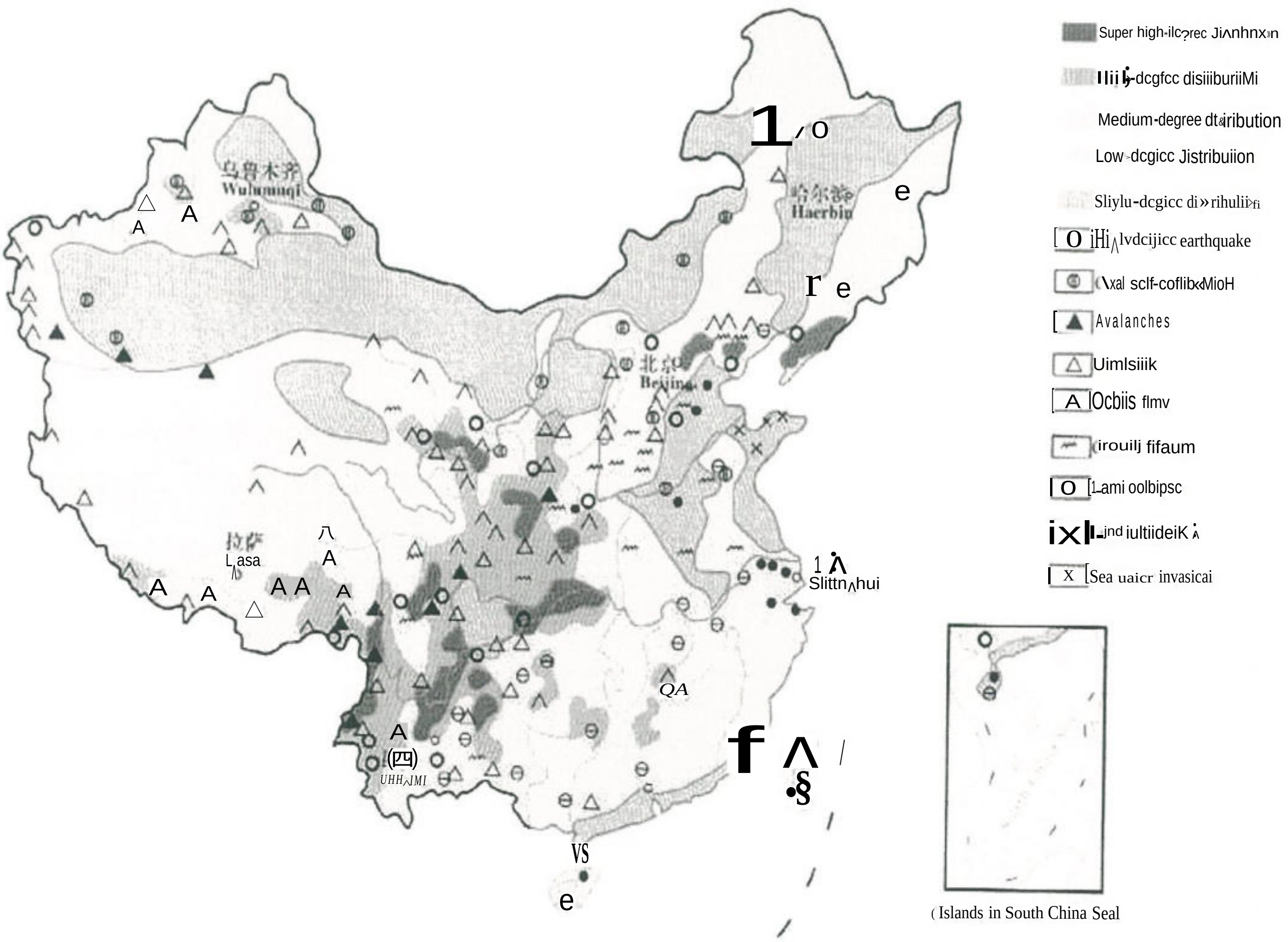
Class Ⅲ: mainly destroy environment and cause damage to resources, like soil erosion, land desertification and coal fire.

Class Ⅳ: combined damaging process, like seawater intrusion.

Earthquakes with Ms ⋀8.0 took place 9 times, with Ms≥7.0 about 80 times (52 times from 1949 to 1990) in the 20th Century. Each Province excluding Zhejiang and Guizhou has earthquakes of Ms ⋀ 6.0. From 1960s, reservoir earthquakes took place at least in 15 reservoirs in 11 provinces (Earthquakes will not be treated in this study because they are managed by the State Bureau of Seismology in China, see Earth Garden at: http://ghyuan.tripod.com/envi/distab.htm, in *Chinese*).

The distribution of main geological disasters is shown in Figure 07.

Figure 07 China's Main Geological Disasters and Distribution [01]



3.1.2. Annual Direct Damages by Geological Disasters

The damages by geodisasters in China are widely distributed (each year and each Province), cause severe losses (casualties, economical and environmental damages) and influence deeply and long-lasting (in time and space scope).

In 2000, based on incomplete statistics, all kinds of geodisasters caused 1080 casualties, disappeared 63 and wounded 26709 persons. The casualties in Shaanxi, Guizhou, Sichuan and Fujian Provinces reached 328, 150, 108 and 88 separately. The average direct economical loss by 15 main geodisasters is about 27 billion *yuan*, see Table 08 (see Earth Garden at: http://ghvuan.tripod.com/envi/distab.htm, in *Chinese*).

A recent investigation organized by the State Bureau of Forestry shown that above a quarter of the total national area is suffering from desertification and causing direct economic loss 54 billion *yuan* annually (see http://finance.sina.com.cn, 18th June, 2000. In *Chinese*). The potential desertification area, i.e., arid, semi-arid and sub-damp arid area is 3.317 million Km^2, sums up 34.6% the total territory. In which the desertification area is 2.62 million Km^2, sums up 27.3% the national area and doubles largely the national cultivated area.

Table 08 Annual Average Direct Economic Losses by 15 Major Geological Disasters

Disaster Types	AA Losses	Note
Avalanche, Landslide, Debris Flow	36	(All units are 0.1 billion *Yuan*) **Class I** Geodisasters Result in Economic Losses of about 5.5 Billion RMB *Yuan*
Land Collapse	4.39	
Land Subsidence	1	
Ground Fissure	0.4	
Earthquake	10	
Tunnel Gas Explosion	0.1	
Water Bursting (Seepage)	3	
Cold Field	30	**Class** II Geodisasters Result in Economic Losses of about 5.5 Billion RMB *Yuan*
Land Salification	25	
Land Desertification	45	**Class** III Geodisasters Result in Economic Losses of about 15.6 Billion RMB *yuan*
Soil Erosion	96	
Coal Fire	15	
Sea Water Intrusion	8	**Class** IV
Total	**274**	

3.2. Present Situation of Geodisaster Management in China

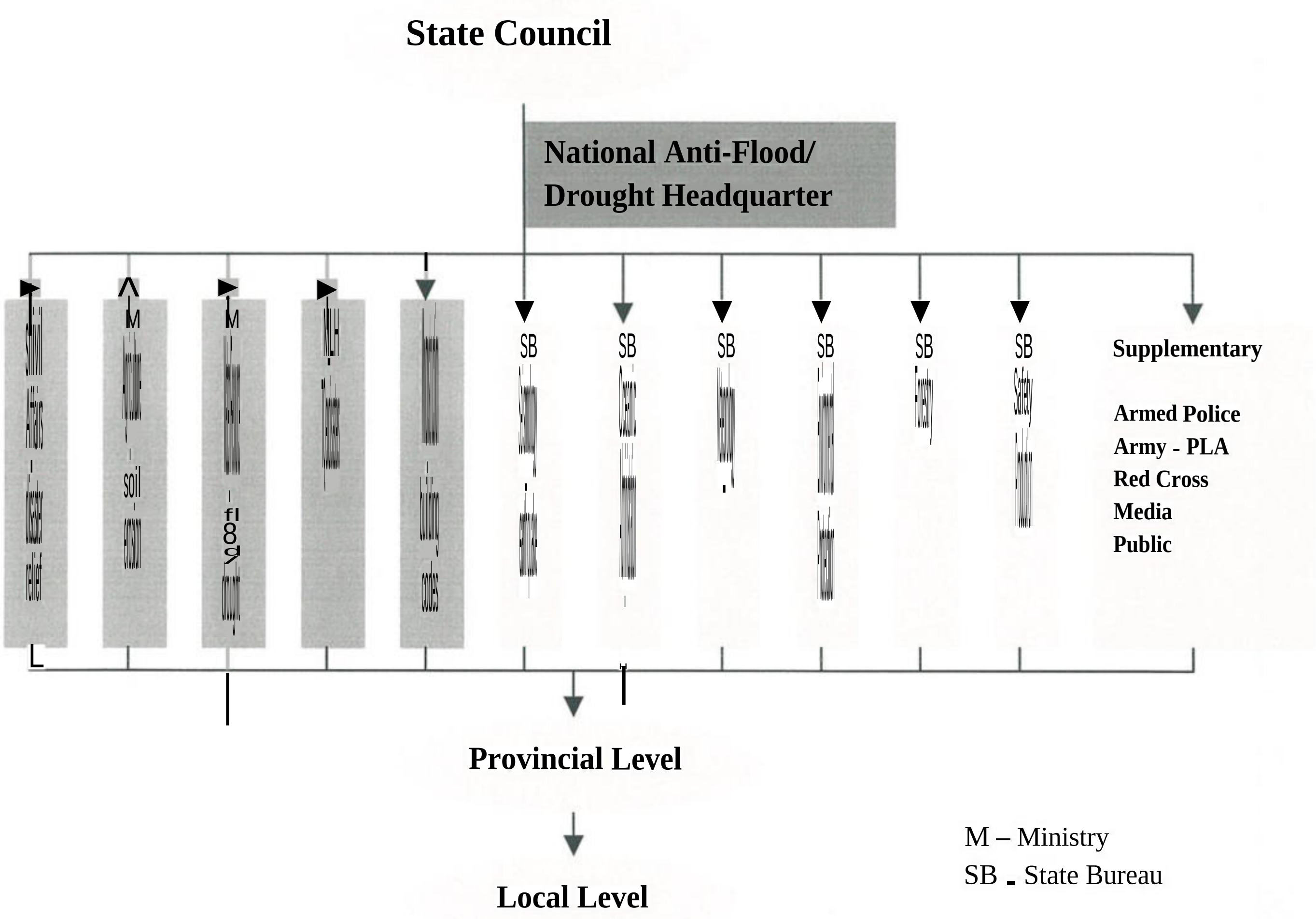
3.2.1. China's Disaster Management System

China's disaster management system is founded based on the types and features of different disasters, and is separated sectorally. Different involved Ministries have their own responsibility over one or several kinds of disasters, without regarding the related causes of possible disasters and the intrinsic relationships in different stages of disaster reduction.

Not like the United States, China doesn't have an authority as FEMA that is in responsible for all kinds of emergency situations. The top body responsible for disasters is the State Council, with an standing organization National Anti-Flood/Drought Headquarter headed by a Vice Premier which is focused mainly on nationwide and trans-regional floods and droughts, now is more involved in other severe disastrous events. The disaster management system is a bit more like that of Australia. Main bodies involved in disaster management are (See Figure 08):

Ministry of Civil Affairs: only responsible for disaster relief.

Figure 08 China's Disaster Management System



Ministry of Agriculture: responsible for floods, droughts (coordinated with Ministry of Water Resources), insect pest, soil erosion, land degradation and other agricultural disasters.
Ministry of Water Resource: responsible for floods and droughts, river, lake and reservoir safety.
Ministry of Land and Resources: responsible for most of the geological disasters.
Ministry of Construction: responsible for building codes related to disaster reduction.
State Bureau (SB) of Seismology: responsible for earthquake.
SB **Oceanic Administration:** supervised by MLR, responsible for marine disasters.
SB Safety Production: responsible for safe production, focused on mine disasters.
SB **Environmental Protection:** responsible for environmental disasters.
SB **Forestry:** responsible for forest fire, forest insect pest and pasture degradation.
SB **Meteorology:** responsible for meteorological disasters and assists in disaster reduction.
At Provincial and local level, similar organizations are established like the Central level in coping with different disasters. Governments at all levels are responsible for all kinds of emergent events of different scales.
In all disastrous events, the Armed Police, Army and other communities always take a great role in China.
China has long been suffered from all kinds of disasters. In the past five decades, the Chinese Government and people have established effective and systematic ways in dealing with disasters based on

the following principles: concentrate on prevention, enforce monitoring, strengthen critical structures and escape (avoid) effectively. Special investigations and harness have been made to over 200 major geodisasters like Lianziya Dangerous Rocks at Three Gorges. Nationwide geoenvironmental monitoring network has been put up preliminarily. Special monitoring and forecasting for major landslides, dangerous rocks, subsidences, land collapses and ground fissures have been set up.

3.2.2. China's Geodisaster Management System

The Department of Geological Environment of Ministry of Land and Resources is the administrative body governing main types of geodisasters in China. Other Departments of MLR involved or coordinated in geodisaster reduction are listed below.

Department of Policy and Legislation
Department of Planing
Department of Land Use Management
Department of Mining Management
Department of Geological Environment
General Division
Division of Geological Environment
Division of Geological Hazards
Division of Monitoring
Bureau of Law Enforcement and Supervision
Department of International Cooperation, Science and Technology

In Bureau of Land and Resources of each Province, there is a similar Division of Geological Environment to be responsible for the geodisaster management at Provincial level. In addition, this function extends to every local level (Counties).

3.2.3. Legislative Establishments for Geodisaster Management in China

Historically, the Chinese Government has paid great attention on the earthquake and other disaster reduction. And thus formed the base of legislative establishments for disaster management. In 1999, the State Council approved the Nationwide Earthquake Reduction Programme, and related regulations governing earthquake management have been issued.

The issue of Regulations on Geodisaster Prevention and Management in 1999 is a turning point for the legal management on geodisasters. Now 19 Provinces have issued local regulations on disaster management. The governance on disaster management has been strengthened, the working rules focused on formulating prevention exercises beforehand (case preparation), rapid report on disaster happening, cruising inspection on emergent situation and 24 hours keep watching at flooding period have been set up. The compulsory regulations on geodisaster assessment at construction sites in disaster prone area have also been established, and the accompanying standards have been set up.

Programme Outline for the Prevention and Cure of Geodisasters (2001 - 2015) has been issued and put into force by MLR this year (2001). This document will guide the geodisaster reduction and management in the coming decade. MLR is also working on the draft Statute on Geodisaster Prevention and Cure, trying to hand into the Legislation Bureau of the State Council, and waiting for the final issue.

BOX 02 Missions of the Ministry of Land and Resources

The mission of MLR as prescribed by the State Council of the People's Republic of China is: To be responsible for the planning, administration, protection and rational utilization of such natural resources as land, mineral and marine resources in the People's Republic of China.

Major functions and responsibilities are:

To enact relevant laws and regulations and promulgate the rules governing the management of land, mineral and marine resources; to be responsible for administrative reconsideration in accordance with relevant regulations, to develop policies regarding the management, protection and rational utilization of land, mineral and marine resources; to formulate the technical criteria, rules, standards and measures for land, mineral and marine resources;

To compile and implement the national comprehensive planning for land and resources, overall plan for land use and other specific plans;

To develop plans for the protection and rational utilization of mineral resources and marine resources, for the prevention and mitigation of geological hazards and for the protection of sites of geological importance;

To supervise and inspect the law enforcement of the departments responsible for land and resources management at various levels and the implementation of plans for land, mineral and marine resources;

To develop policies and regulations concerning cultivated land, especially those that protect and encourage the development of cultivated land;

To formulate cadastral regulations, organize land and resources survey, cadastral survey, land statistics and dynamic monitoring; to administer land titles, land grading and registration;

To develop and implement the regulations for the assignment, lease, evaluation, transfer, transaction and governmental purchasing of allocation of the right to the use of land;

To administer the evaluation of land pricing (basic price and standard price), validate the qualification of the land evaluation and appraisal organizations, and confirm the land-use prices;

To supervise the examination, approval, registration and licensing of the rights to explore and to mine *the* mineral resources and the transfer of the rights, to examine and approve blocks open to foreign and investment; to undertake the management of mineral reserves and the collection and compilation of geological data; to administer, according to law, the geological exploration work, to examine and determine the qualifications of geological exploration organizations and manage results of geological exploration;

To organize the monitoring, prevention and mitigation of geological hazards and the protection of sites of geological importance; to supervise according to law the hydrogeological, engineering geological and environmental geological exploration and evaluation, to supervise the monitoring and prevention of the over extraction and contamination of groundwater, and protect geological environment;

To arrange, supervise and inspect the use of the state funds for geological exploration and other related funds;

To organize overseas cooperation and exchange in the field of land, mineral and marine resources;

To perform other duties assigned by the State Council;

Managing the State Oceanic Administration and the State Bureau of Surveying and Mapping in accordance with the relevant provisions of the State Council.

3.3. Building An Integrated Assessment System Towards Sustainable Management

With so many geodisasters, it's impossible for the Government to seek and spend enough funds in disaster reduction, as China is still a developing country. So which is the most urgent situation? For a certain geodisaster, what are the possible economical, social and environmental effects for different reduction (cure) scenarios? Which disasters (in where?) should be coped firstly under limited investment? These questions should be answered firstly in a sustainable disaster management system.

For this purpose we have been trying to build an integrated disaster assessing system involve disaster identification (fatalness) analysis, vulnerability analysis, (expected annual) damage analysis and disaster mitigation (especially for engineering measures, also in most of the circumstances) cost-benefit analysis. Moreover, at the last stage, put the assessment with different scenarios of various criteria into a decision support system. In this way, we can help decision-makers in their management of different geodisasters.

BOX 03 Distribution of Main Geodisasters in Three-Gorges Area

(Ref, http://www.cigem.gov.cn/jcy/homepage/dzzh/sxdzzhgk.htm)

4. An Analysis of Disaster Management Approaches in Western Countries

Disaster management is a very complicated topic, including both natural and social affairs divided into technological aspects, institutional aspects and legislative (also policy) aspects. In most of the Western countries, disaster management is integrated in emergency management. So their management systems include all kinds of disasters, both natural and man-made. Here attention is paid on risk management and civil protection in EU countries. For Canada, its emergency management system is framed; and for US, its newly issued landslide management strategy is illustrated, trying to figured out some common issues that may be integrated into a geodisaster management system for China.

4.1. European Countries

4.1.1. Main Types of Disasters in EU and Technological Aspects

EU is very experienced in using all kinds of technologies in dealing with disaster problems, focused on the using of EO and all kinds of images in hazards monitoring and mapping, GIS and DSS in disaster management processes, both hardware and software.

Technologically, the still in processing project Formidable shows a good example of how the EU regime is trying to integrate the technological, institutional (and legislative) aspects into a disaster management system. FORMIDABLE (Friendly Operational Risk Management through Interoperable Decision Aid Based on Local Environment. See http://www.formidable-project.org) is a joint European project, that based on the experiences of the different partners, focuses on the definition of a standardised approach to the emergency management of any type of natural disaster for the European Civil Protection Authorities (CPAs). The major components of the FORMIDABLE project consist of a standard methodology, with guidelines, templates and recommendations about the CPAs activities in the emergency management; a prototype of a decision support system, which translates the methodology into standardised information and communication procedures, and integrates it with advanced technology, in order to improve the user-friendliness, the flexibility and the reliability of such a system (Figure 05)[041].

According to a recently completed project (Risk assessment procedures used in different EU countries (including Norway), see also http://europa.eu.int/civil/prote/cpactiv/cpact02b.htm)[16], the main types of disastrous accidents identified in EU Countries are shown in table 09. The main geodisasters are earthquakes, avalanches, landslides and volcanoes.

Table 09 Main Types of Disastrous Accidents Identified in EU Countries [16]

Country	AU	BE	DK	FI	FR	GE	GR	IR	LU	XL	NO	PT	UK
Hazards													
Fire	X	X	X	X		X		X		X	X	X	
Explosion	X	X	X	X		X				X		X	
Transp.Haz-inat	X	X		X		X					X		
Road		X	X	X	X	X	X	X		X	X		X
Railway		X	X	X		X		X		X	X		X
Airplane		X				X		X		X			X
Sea							X	X		X			
Gas emission	X	X		X		X				X	X	X	X
Fluid emission		X	X	X		X			X	X	X	X	X
Industrial	X	X		X				X	X		X	X	X
Water pollution.	X									X			
Nuclear emiss.										X			X
Floods	X				X	X	X		X	X	X		X
Avalanches	X				X				X				
Cyclones					X								
Land-slide	X				X						X		
Earthquakes	X				X		X			X			
Volcanoes					X		X						
Forest fires				X		X	X						
Extreme weath.						X	X	X		X			
Tunnels											X		

(See also Table 10)

4.1.2. Risk Assessment Methods

In EU, risk assessments for civil protection in emergency management is used for the following purposes [16]: identification and classification of risks, hazard type/seriousness evaluation, accident prevention, consequence analysis and consequence restriction, developing the emergency preparedness in general, forming basis for emergency planning, risk communication, risk scenarios evaluation and dimensioning of response forces.

At the practical level, the qualitative risk assessments are used in setting of reaction and disaster preparedness. In all the countries, risk assessment is a legislative obligation for some specific industries installations. In some of the countries, the local authorities - usually the municipalities . are obliged to study the risks in their own area. These countries are Finland, Germany, Greece, the Netherlands and Norway.

In most countries, industry can choose to use whatever they like of the different quantitative risk assessment methods. The practical work is usually carried out by the consultants. In many countries, authorities can get the results of the risk assessments done by the industry and take advantage of them in the public emergency management. In Greece and Ireland only public authorities are responsible for carrying out risk assessments in their areas but industry has to provide them with all the information needed.

The risk assessment methods used were divided into qualitative and quantitative ones in the following way (See Table 10):

Qualitative risk assessment methods

. General methods
. Identification of risks
. General assessment of the consequences of identified risks
. Other methods

Quantitative risk assessment methods

. HAZOP
. Probabilistic risk assessment
. Fault tree
. Event tree
. Human error analysis
. Environmental risk assessments
. Other methods

The favourite risk assessment methods for each country are shown in Table 10.

Table 10 Summary of Different Methods Used in EU Countries [16]

Methods	AU	BE	DK	FI	FR	GE	GR	IR	NL	NO	PT	SW	UK
Qualitative													
General methods	X	X		X	X	X		X		X	X	X	X
Identification of risks	X	X	X	X	X	X		X	X	X	X	X	X
Consequence assessm.	X	X	X	X	X	X	X	X	X	X	X	X	X
Other methods		X				X					X	X	
Quantitative													
HAZOP		X		X					X	X	X	X	
Probabilistic r.a.	X			X					X	X		X	
Fault tree		X		X					X	X	X	X	
Event tree	X	X		X					X	X	X	X	
Human error analysis	X	X		X						X		X	
Environmental r.a.	X	X		X					X	X	X	X	
Other methods		X					X						

Explanation: AU= Austria, BE= Belgium, DK= Dermark, FI= Finland, FR= France, GE= Gerwcmyf GR= Greece, IR= Ireland, ArI= (he Netherlands, NO= Norway, PT= Portugal, SW= Sweden, UK= the United Kingdom.

4.1.3. Risk Assessment Procedures Used in Finnish Rescue Services [16]

In Finland, risks relate to natural hazards include: earthquake, landslide, land-slip, rockfalls, flooding, heavy rain, wind, typhoons, hurricanes, waves, tsunamis, other extreme weather or natural conditions, etc.

The basic ideas of the risk assessment procedure applied follows the Swedish example of risk assessment on a local level (Hazard Identification and Evaluation in a Local Community, UNEP IE/PAC 1992, pp.17-47). The main difference between the Finnish and Swedish systems of municipal risk assessments is that in Finland these assessments form an official basis for the decision making on dimen.

sioning of the resources for Civil Protection in the municipalities. In Sweden, risk assessments serve more as guidance in each municipality with no obligations to budgetary decision making.
The phases of risk assessment procedure applied for in the preparedness planning are:
a) Risk identification and analysis of the risk objects
b) Risk management: possible risk reduction measures and arrangements, defining and planning of the rescue operations, rescue service and resources needed according to the analysed risks and risk objects
c) Risk financing policies
At the first stage of the procedure, all possible risks in a certain municipality or co-operation area are identified. At the second stage of the risk assessment procedure, the probabilities of different risks are estimated. At this stage a certain calculation method is used in order to get a numerical risk estimate for each possible risk.
The calculation of risk is usually done by multiplying the possible consequence of the risk by the probability of the risk:

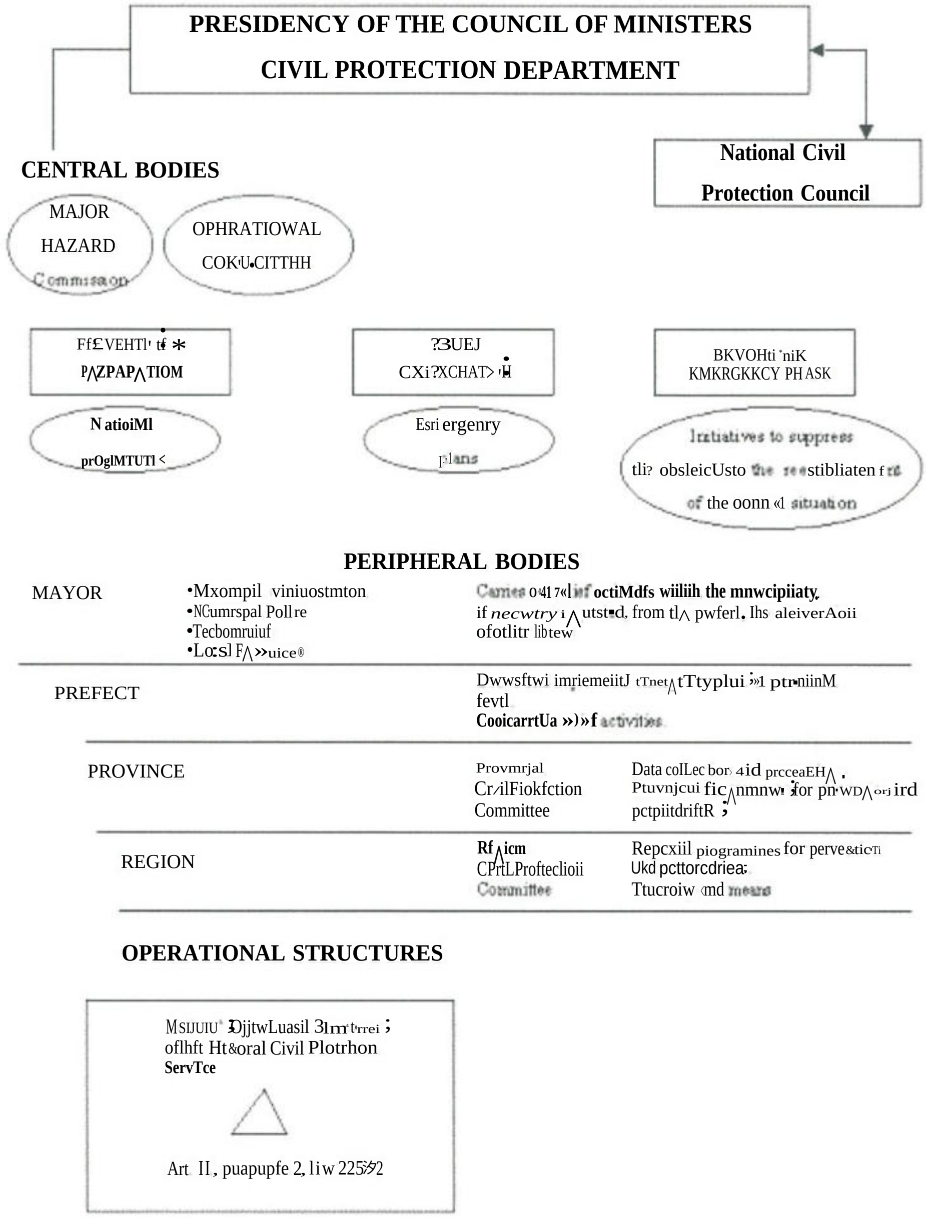
Risk = Consequences ^ Probability

The consequences can be deaths, injuries, property losses, interruption losses and environmental damages. The consequences are influenced by the rapidity of which the accident is developed and progressed.
The two stages - risk identification and probability estimation . form a core of the risk assessment procedure. It is obvious though that this entity can be described more or less as a risk inventory not an assessment in a more sophisticated sense. After the risk assessment itself is done a third stage of the procedure follows, which is the choice of risk management method. This means choosing the method that is economically most effective from the municipal point of view. As a last stage a plan for developing the risk assessments and the follow up is presented.

4.1.4. The Italian Disaster Management System

In Italy the national organisation responsible for the management of natural disasters is the National Civil Protection Service (Servizio Nazionale Della Protezione Civile) which was set up by statute in 1992. This Service was set up with the responsibility for "protecting the integrity of life, assets, settlements, and the environment from damage resulting from natural disasters, catastrophes, and other calamities"[19].
The Dipartimento della Protezione Civile [Civil Protection Department], an operations committee of the National Civil Protection Service, is responsible for responding to requests for emergency assistance and for co-ordinating the interventions of all other administrations and bodies concerned. The other national organisations involved in emergency management are: fire fighting organisations; the armed forces; the police; the State Forestry Corps; the national technical services; national scientific research groups including the National Institute of Geophysics; the Italian Red Cross; the national health service departments; volunteer organisations and the National Alpine Aid Corps (CNSA).
Below national level the Civil Protection Service is organised into regional (plus 2 provincial offices) and local offices. At regional level the Prefect is responsible for emergency planning, at local level this is done by the Mayor. The overall organisation for emergency management and civil protection in Italy is shown in Figure 09.
All the 20 Regions in Italy also have centralised responsibilities for disaster management. They are responsible both for the organisation and implementation of civil protection activities and for ensuring the best use of their resources.

Figure 09 Organisation of Emergency Management and Civil Protection in Italy [19]



Italy is potentially subject to a number of natural hazards which require a separate approach with regard to emergency planning and management. These natural hazards are: volcanic, seismic, forest fires, landslides and flooding etc.

Based on the type of event (geographic area and severity), the legal bodies and fields of responsibility vary by determining a different level of disaster management.

Events are subdivided into three different categories:

A. . ordinary: co-ordinated and executed by a single body;

B. - ordinary: co-ordinated by a single body, executed more than a single body;

C. . extraordinary.

Regulations for the detailed definition of responsibilities, tasks, and organisation of the various bodies are currently being developed.

Volcanic risk management: Monitoring takes place on a permanent basis through extensive in situ sensing systems. Osservatorio Vesuviano [Vesuvian observatory], administered by the Ministero per la Ricerca Scientifica [ministry for scientific research], is responsible for monitoring Vesuvius and the area of Campi Flegrei (both in Campania region, southern Italy). The Istituto Intemazionale di Vulcanologia [national volcanology institute], administered by the C.N.R. (Consiglio Nazionale delle Ricerche), monitors Etna and also manages the control networks installed on the Aeolian Islands.

Seismic risk management: The Civil Protection Department's scientific operative branch - Gruppo Nazionale Difesa Terremoti (GNDT, national earthquake defence group) - co-ordinates and gathers data from all major authorities in this area, such as the Consiglio Nazionale delle Ricerche (CNR, National Research Council) and from major university institutions to gain an overview of the main lines of research and modelling. The CNR collaborates directly with Commissione Nazionale Previsione e Prevenzione Grandi Rischi (National Commission for the Forecasting and Prevention of Large Risks), with which it develops prevention and emergency plans.

Flooding and landslide risk management: As with seismic risks, the CNR collaborates with Commissione Nazionale Previsione e Prevenzione Grandi Rischi (National Commission for the Forecasting and Prevention of Large Risks) to develop prevention and emergency plans. A number of scientific research bodies, such as the Gruppo Nazionale per la Difesa dalle Catastrofi Idrogeologiche (GNDCI, National Hydrogeological Disaster Defence Group), co-ordinate and gather information in this area to gain an overview of the main lines of research and modelling. In 1989 the River Authorities were established aimed at land defence. Italy's territory was classified into basins of national, regional and interregional importance based on the size of the basin. Basin authority bodies have the goal of understanding, compiling directives for land defence and planning land intervention works.

Weather forecast data is provided by the Servizio Meteorologico Nazionale (National Meteorological Service) directly to institutions such as the civil protection department, hydrological service and fire brigades.

For a more detailed emergency management process in Italy, please see ref [19].

4.2. The US, Canadian Ways

4.2.1. Some Institutional Aspects of US Disaster Management

Based on the Stafford Act of the United States, FEMA is the authority responsible for emergency events and the main coordinator for disaster management. The USGS is the recognized authority for understanding landslide hazards in the United States and the long time leader in this area. The USGS derives its leadership role in landslide hazard related work from the Disaster Relief Act of 1974 (Stafford Act). The Director of the USGS has been delegated the responsibility to issue disaster warnings for an earthquake, volcanic eruption, landslide, or other geologic catastrophe consistent with the 1974 Disaster Relief Act 42 U.S.C. 5201 et seq [17]. Now they are preparing Disaster Mitigation Act of 2000 to amend the 1974 Act (See Impacts of the Disaster Mitigation Act of 2000 on FEMA Mitigation and Response and Recovery Programs, a PowerPoint at www.fema.gov).

The following part will take the National Landslide Hazards Mitigation Strategy [18] as an example to analyze.

The National Landslide Hazards Mitigation Strategy [18] is prepared by USGS on behalf of the large multisector, multi-agency stakeholder group involved in landslide research and mitigation nationwide.

It builds on the principles, goals and objectives of the National Mitigation Strategy - Partnerships for Building Safer Communities developed in 1996 by the Federal Emergency Management Agency (FEMA) to encourage mitigation of all forms of natural hazards in the United States.

4.2.2. Landslide Hazards Mitigation Strategies [18]

Landslide risk can be reduced by five approaches used individually or in combination to reduce or eliminate losses.

Restricting Development in Landslide-Prone Areas - Land use planning is one of the most effective and economical ways to reduce landslide losses by avoiding the hazard and minimizing the risk. This is accomplished by removing or converting existing development or discouraging or regulating new development in unstable areas. In the United States, restrictions on land use generally are imposed and enforced by local governments by means of land use zoning districts and regulations. Implementation of avoidance procedures has met with mixed success. In California, extensive restriction of development in landslide-prone areas has been effective in reducing landslide losses.

Codes for Excavation, Construction, and Grading Codes . Excavation, construction, and grading codes have been developed for construction in landslide-prone areas. There is no nationwide uniform code to ensure standardization in the United States; instead, State and local government agencies apply design and construction criteria that fit their specific needs. The city of Los Angeles has been effective in using excavation and grading codes as deterrents to landslide activity and damage on hillside area. The Federal government has developed codes for use on federal projects. Federal standards for excavation and grading often are used by other organizations in both the public and private sectors (NRC Committee on Ground Failure Hazards, 1985).

Protecting Existing Development - Control of surface water and groundwater drainage is the most widely used and generally the most successful slope-stabilization method (Committee on Ground Failure Hazards 1985). Stability of a slope can be increased by removing all or part of a landslide mass, or by adding earth buttresses placed at the toes of potential slope failures. Restraining walls, piles, caissons, or rock anchors are commonly used to prevent or control slope movement. In most cases, combinations of these measures are used.

Monitoring and Warning Systems . Monitoring and warning systems are utilized to protect lives and property, not to prevent landslides. However, these systems often provide warning of slope movement in time to allow the construction of physical measures that will reduce the immediate or long-term hazard. Site-specific monitoring techniques include field observation and the use of various ground motion instruments, trip wires, radar, laser beams, and vibration meters. Data from these devices can be telemetered for real-time warning.

Development of regional real-time landslide warning systems is one of the more significant areas of landslide research.

Landslide insurance and compensation for losses . Landslide insurance would be a logical means to provide compensation and incentive to avoid or mitigate the hazard.

Society is far from helpless in the face of these prospects. Improvements in our scientific understanding of landslides and other ground failure hazards can provide more accurate delineation of hazardous areas and assessments of their hazard potential. This information can be developed in a form and at a scale that is meaningful and useful for decisionmaking. Cost-effective actions can be taken to reduce the loss of lives and property, damage to the environment, and economic and social disruption caused by landslides and other ground failures. Government at all levels plays critical roles in advancing landslide hazard mitigation and developing programs and incentives that encourage and support community-based implementation. A national strategy to reduce losses from landslides and other ground failures must have both research and implementation components to increase understanding of landslides and other ground failures and put existing knowledge to use to reduce losses. Developing durable and comprehensive solutions to landslides and other ground failure hazards will require a continuing dialogue among and concerted action by all sectors of our society.

The long-term mission of the strategy is to provide and encourage the use of scientific information, maps, methodology, and guidance for emergency management, land-use planning, and development and implementation of public and private policy to reduce losses from landslides and other ground failure hazards nationwide.

4.2.3. Elements and Objectives of the US Strategy [18]

1). Research: Developing a predictive understanding of landslide processes and triggering mechanisms led by USGS.

2). Hazard Mapping and Assessments: Delineating susceptible areas and different types of landslide hazards at a scale useful for planning and decision-making, led by USGS and State geological surveys.

3**). Real-Time Monitoring:** Monitoring active landslides that pose substantial risk led by USGS.

4). Loss Assessment: Compiling and evaluating information on the economic impacts of landslide hazards led by FEMA and insurance industry.

5). Information Collection, Interpretation, Dissemination, and Archiving: Establishing an effective system for Information Transfer, led by USGS and State geological surveys.

6). Guidelines and Training: Developing guidelines and training for scientists, engineers, and decisionmakers, led by USGS and professional societies.

7). Public Awareness and Education: Developing information and education programs for the user community, led by FEMA and USGS.

8). Implementation of Loss Reduction Measures: Encouraging mitigation action, led by FEMA, State departments of emergency services, and professional societies.

9). Emergency Preparedness, Response, and Recovery: Building resilient communities led by **FE-**MA and State departments of emergency services. See Table 11.

Table 11 Roles and Opportunities under the National Landslide Hazards Mitigation Strategy [18]

<table>
<tr><th rowspan="2">ELEMENT</th><th rowspan="2">CURRENT STATUS</th><th colspan="5">New Roles and Partnership Opportunities</th></tr>
<tr><th>Federal</th><th>State</th><th>Local</th><th>Private</th><th>Academic</th></tr>
<tr><td rowspan="3">1) Research: Developing a predictive understanding of landslide processes and triggering mechanisms.</td><td rowspan="3">A much more comprehensive understanding of landslide processes and mechanisms is required to advance our ability to predict the behavior of differing types of landslides.</td><td colspan="2">Coordinate research priorities.</td><td colspan="3"></td></tr>
<tr><td colspan="5">Conduct research.</td></tr>
<tr><td colspan="4">Use results of research in policy, planning, and mitigation decisions.</td><td></td></tr>
<tr><td rowspan="4">2) Hazard Mapping and Assessments: Delineating Susceptible areas and different types of landslide hazards at a scale useful for planning and decisionmaking.</td><td rowspan="4">Landslide inventory and landslide susceptibility maps are critically needed in many landslide prone regions of the nation. In general, there are no standards for mapping and assessments.</td><td>Map landslides on Federal lands.</td><td colspan="4"></td></tr>
<tr><td colspan="2">Establish mapping and assessment standards.</td><td colspan="3"></td></tr>
<tr><td colspan="5">Map and assess landslide hazards.</td></tr>
<tr><td colspan="5">Use landslide hazard maps and assessments in planning, preparedness, and mitigation.</td></tr>
<tr><td rowspan="2">3) Real-Time Monitoring: Monitoring active landslides that pose substantial risk.</td><td rowspan="2">Real- time monitoring active landslides is critically needed nationwide.</td><td colspan="5">Improve real-time monitoring capabilities.</td></tr>
<tr><td colspan="4">Monitor landslides and establish landslide warning systems.</td><td></td></tr>
<tr><td rowspan="2">4) Loss Assessment: Compiling and evaluating information on the economic and environmental impacts of landslide hazards.</td><td rowspan="2">Losses are not consistently compiled and tracked in the U.S.</td><td>Establish and implement a national strategy for compilation, maintenance, and evaluation of data.</td><td colspan="4"></td></tr>
<tr><td colspan="5">Compile and share records of losses.</td></tr>
<tr><td>5) Information Collection, Interpretation, Dissemination, and Archiving: Establishing an effective system for information transfer.</td><td>No systematic collection and distribution of landslide hazards information nationwide.</td><td colspan="2">Develop robust landslide hazards information clearinghouse system for the systematic collection, interpretation, archiving and distribution of scientific and technical information, databases, and maps.</td><td colspan="2">Collect and distribute needed information to decisionmakers.</td><td>Develop and share information.</td></tr>
</table>

6) Guidelines and Training: Developing guidelines, training for scientists, engineers, and decision makers.	Critical need for guidelines and training for scientists, engineers, planners and decision makers.	Develop and implement guidelines and training curriculums.			
		Participate in training programs.			
7) Public Awareness and Education: Developing information and education for the user community.	Little public awareness and understanding of landslide hazards, impacts on communities, and options for reducing risk.	Develop and implement public awareness and education programs, involving land use planning, design, and landslide hazard curriculums, landslide hazard safety programs, and community risk reduction.			
8) Implementation of Loss Reduction Measures: Encouraging mitigation action.	Mitigation necessarily occurs at the local level, therefore, implementation of landslide hazards loss reduction measures varies from community to community.	Develop and encourage policies that support landslide hazard mitigation. Develop financial incentives and disincentives that support landslide hazard mitigation. Develop and encourage engineering and construction approaches to mitigate landslide hazards.	Adopt and implement policies and practices that support landslide hazards mitigation.		
				Serve as consultants and advisors.	
9) Emergency Preparedness, Response, and Recovery: Developing resilient communities.	Federal, State and local governments, the private sector, and the public need to be able to adequately prepare, respond to, and recover from landslide emergencies.	Provide training for Federal, State and local emergency managers. Develop a coordinated landslide rapid response capability, including landslide hazards expertise and equipment required for rapid emergency deployment of real-time data to emergency managers.	Participate in training.	Provide expertise during emergencies.	
			Effectively respond to landslide emergencies. Implement policies that reduce future landslide losses.		

4.2.4 Canada Emergency Management System [19]

Canada has significant problems with floods, tornadoes, avalanches and landslides, earthquakes and ice, snow and hail storms (http://earth.esa.int:1025/DISMAN/docs/ROOTFQLDER/SRCanada.htm).

The Office of the Privy Council - responsible for supporting the Prime Minister and Cabinet, overseeing the Federal Government and assisting the co-ordination of new legislation in the Cabinet. In addition, the Office informs the Prime Minister about matters relating to civil emergency planning and emergency response, and ensures co-ordination of the response efforts between the Prime Minister and the lead department.

The Federal Departments and Agencies , have standing arrangements for meeting their departmental mandates, and make plans for response in accordance with the Emergency Preparedness Act. Several federal departments have civil emergency planning resources at the national offices, others at the regional and local level.

Emergency Preparedness Canada - Emergency Preparedness Canada (EPC) is located within the Department of National Defence and reports to the Deputy Chief of the Defence Staff. It provides direct support to the Minister Responsible for Emergency Preparedness (MREP). Emergency Preparedness Canada, in co-operation with the provinces, has the following responsibilities:

Advancing the state of civil emergency planning in Canada;
Providing financial programs for the attainment of a uniform standard of national preparedness;
Alleviating the costs of post-disaster recovery;
Administering "The Canadian Emergency Preparedness College" located in Amprior, Ontario that conducts courses and provides training in various aspects of emergency preparedness and response.
In times of emergency, the Federal Government, under the leadership of the designated lead minister, establishes a National Support Centre (NSC) to manage federal participation. For larger events that occur within federal jurisdiction and that involve a number of federal/provincial agencies, response is co-ordinated by a designated lead department. The lead department then manages the operation with the support of other federal agencies and perhaps some provincial or local support. EPC assists the lead departments by providing access to regional or national civil emergency planning networks, and by supplying the Minister Responsible for Emergency Preparedness (MREP) with information related to the situation. Should an event occur within federal jurisdiction for which there is no provisionally designated lead department, Emergency Preparedness Canada co-ordinates the initial federal response, see Figure 10.
From above we can see that Canadian disaster emergency management system is much the same as that of the US.
For the disaster management systems of Germany, Italy and France, please visit the website referenced in [19].

4.3. Brief Comparison of Disaster Management Between China and Western Countries

For a brief comparison of the disaster and emergency management between China and Western countries, we can conclude:

A. The Chinese Governments at every level have paid great attention to disaster and emergency management, and have achieved great in this area. But China does not have an authorized emergency management body, not like the situations of the US, Canada, Italy and other countries.

B. China's disaster management is separated, even for the management of main types of geodisasters. The management is not based on the intrinsic relationships of disasters, not easy to coordinate when emergency happens.

C. For disaster research and emergency management, RS and GIS are widely used in the Western countries. In this aspect, China had to quicken its pace, especially in the using of remotely sensed data for emergency management.

D. China's legislative process for disaster and emergency management lies far behind that of the Western countries. In this area, the Western experiences especially those of Italy, Canada and the US can be of reference, see Table 12.

Figure 10 Canada Emergency Response Flow [19]

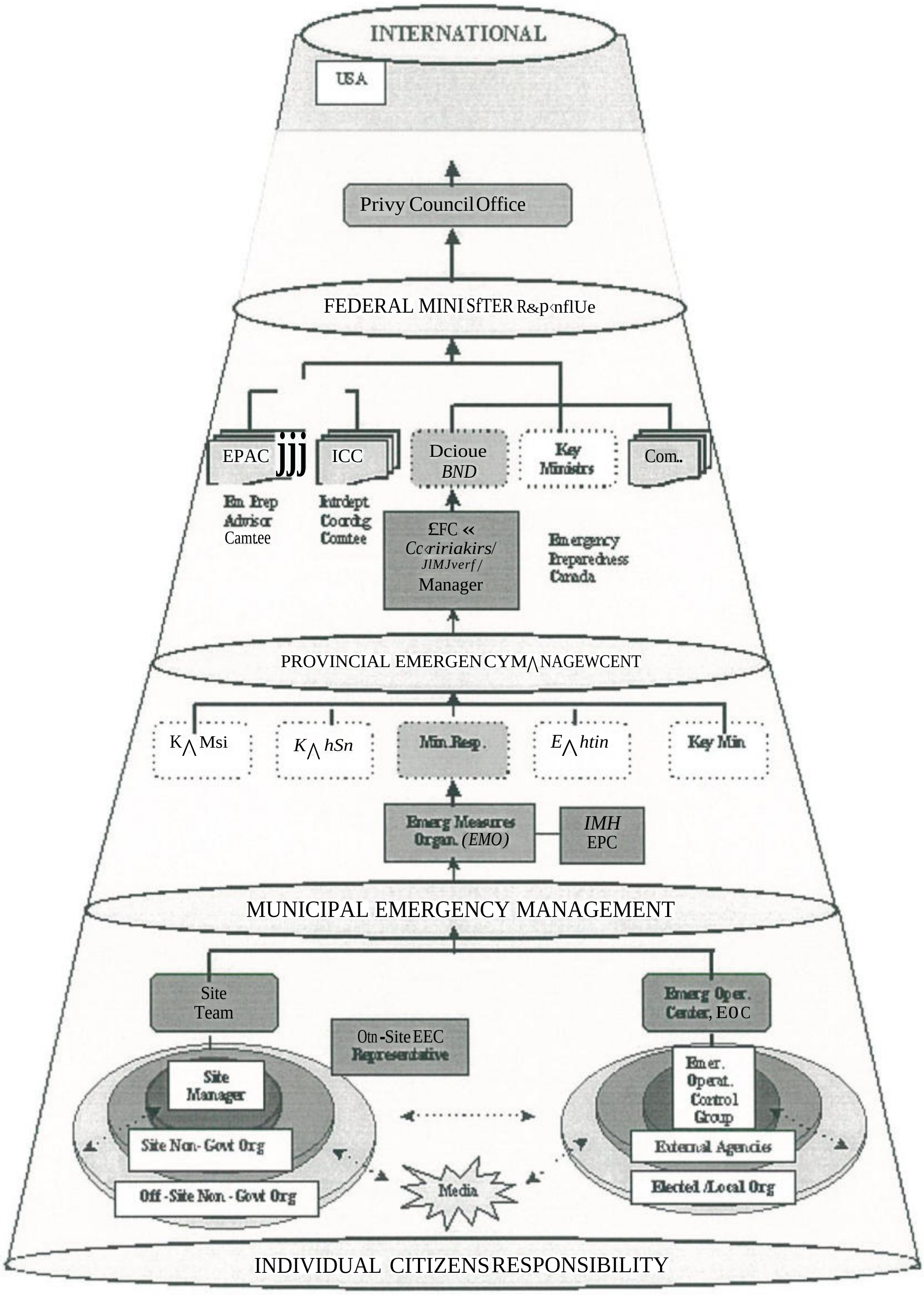


Table 12 Disaster and Emergency Management Between China and Western Countries*

Items		China	Canada	US	Germany	Italy	EU Proposed
[illegible]	Authorized Coordinator	No. MCA is responsible for relief.	EPC -H-	FEMA +++	No. Mainly in States. Ministries of environment, finance, construction and transport take a lead role.	DPC +++	
	Geodisaster	MLR	EC?	USGS		CNR, GNDCI etc	
	Framework	Figure 08	Figure 10 Ref [19]	Ref Table 11 and Figure 09	Ref [19]	Figure 09 Ref [19]	
Technology / Operation	RS, GIS	Yes +	Yes +++	Yes +++	Yes +++	Yes +++	Yes
	Monitoring	Yes -H-+	Yes +++	Yes ++	Yes ++?	Yes +++	Yes
	Preparedness	+++	+++	+++	++	+++	
	Mitigation	++	+++	+++	+++	+++	
	Relief	+++	+++	+++	+++	+++	
	DB & Info	+	-H-+	+++	++	+++	
	Integrated Assessment	+++	++	++?	++?	+++?	
	Management Integration	+	+++	+++	++	+++	
Legislative	Nation Law	No	Yes	Yes	Each State has its own emergency legislation which defines the responsibilities between regional and local level.	Yes?	
	State Law	No	Yes?	Yes		Yes	
	Regulation	Yes +	Yes +++?	Yes +++		Yes +++?	
Sustainable Development		+	+++	-H-	+++	+++	+-H-

Note: Yes - have, No - Without, + - good, ++ - better, +++ - best, ?– Not sure

There are a wide range of techniques and methods for impact assessment which are available to undertake EIA. The same techniques can be applied to the assessment of indirect and cumulative impacts and impact interactions.

They can be divided into those that are analytical or quantitative in nature and those that are planning orientated:

Analytical Methods	Planning Methods
Spatial Analysis	Multi-criteria evaluation
Network Analysis	Programming models
Biogeographic Analysis	Land suitability evaluation
Interactive Matrices	Process guidelines
Ecological Modelling	
Expert Opinion	

In practice, the application of these techniques for the identification and assessment of impacts is either limited or has not been developed to its full potential.

5. Conclusions and Recommendations

5.1. Some Conclusions

A. China has long been suffered from different kinds of disasters historically. The Chinese people have gained lots of experiences in dealing with all kinds of disasters. But as the population and economy grow, the damage by different disasters also increases.

Disaster is first a socio-economical problem. As a developing country, China's resources in dealing with disasters are still very limited. So the Authorities have been trying to find a most effective way in coping with disasters, by developing an integrated disaster management towards sustainable development.

B. China's geodisasters can be divided into 10 groups and 31 types. China has totally more than 3,000 major avalanches, 2000 landslides, 2000 debris flows, and more than tens of thousands medium-small sized avalanches, landslides and debris flows. In China, more than 400 counties and 10,000 villages are threatened, among which, above 60 cities and towns are frequently intruded by landslides and avalanches, more than 50 cities and towns are frequently intruded by debris flows. About one third of China's total territory is suffering from land degradation and soil erosion. It is reported that the desertification causes a direct economic loss of 54 billion *yuan* annually. The annual average losses by main geodisasters are about 27 billion *yuan* China's disaster statistic system needs to be improved.

China has finished 1: 200,000 hydrogeological and engineering geological mapping in the past five decades. 25 Provinces (Autonomous Regions and Cities) have finished 1: 500,000 environmental geology investigations. All these achievements lead to the understanding of the background, causes, occurrences and development of different kinds of geodisasters nationwide, and lay a good base for disaster management.

C. China's disaster management system is founded based on the types and features of different disasters, and is separated sectorally. Different involved Ministries have their own responsibility over one or several kinds of disasters, without regarding the related causes of possible disasters and the intrinsic relationships in different stages of disaster reduction.

Not like the United States, China doesn't have an authority as FEMA that is in responsible for all kinds of emergency situations. The system differs from that of most of the Western countries, is a bit more like that of Australia.

Ministry of Land and Resources is responsible for main geodisaster types. Now special investigations and harness have been made to over 200 major geodisasters like Lianziya Dangerous Rocks at Three Gorges. Nationwide geoenvironmental monitoring network has been built preliminarily. Special monitoring and forecasting for major landslides, dangerous rocks, subsidences, land collapses and ground fissures have been set up. Geodisaster management rules have been drawn up following the principle: concentrate on prevention, enforce monitoring, and strengthen critical structures and escape (avoid) effectively.

China still lacks of coordinated disaster and emergency management laws and regulations. The Regulations on Geodisaster Prevention and Management was issued by MLR in 1999. Now 19 Provinces have issued local regulations on geodisaster management. The compulsory regulations on geodisaster assessment at construction sites in disaster prone area have also been established, and the accompanying standards have been set up. MLR is now working on the draft Statute on Geodisaster Prevention and Cure, trying to hand into the Legislation Bureau of the State Council, and waiting for the final issue.

D. The building of an integrated decision-makers oriented disaster assessment system is essential for China's geodisaster management. We have been trying to build the system with four main parts: fatalness (seriousness, identification) assessment, vulnerability assessment, damage assessment and benefit/cost assessment. Now I'm trying to add a multi-criteria assessment directly connecting to decision-makers into the system. Thus forms a DSS for disaster management. For regional disaster assessment, the results can be included in disaster-economical zonation [20].

Advanced technologies are involved in the system, especially RS and GIS. Remotely sensed images should be used especially in local and regional assessment for disasters like landslide, debris flow, land collapse etc. Data depository should be improved for the system.

E. The experiences of Western countries in disaster and emergency management are also very important for China's disaster management. Though the Western countries' disaster management systems differ, they are very experienced in institutional coordination, disaster management legislation and also in technological aspects. From the above analysis, the experiences for disaster and emergency management of the US, Canada and Italy are more suitable for China.

5.2. Recommendations

As disaster is firstly a socio-economical problems and all disasters are dealt within different socio-economical background, it's necessary for disaster research and education to include and/or focus on the socio-economical aspects of disaster management.

The building of an integrated geodisaster management system for China is a challenging task of Chinese Authorities and related organisations. Efforts should be made in technological, institutional and legislative aspects, and improvements also needed for our integrated disaster assessment system. Co-operation on geodisaster management between China and the Western countries would be a good idea, and will be of great help to China's disaster management. I'm trying to seek the opportunities for co-operated projects between MLR and ITC or other organisations in EU. Any suggestions are welcome. Please reach me at http://ghyuan.tripod.com/indexe.html or write me at ghyuan@yahoo.com.

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