

# Seismic Hazard and Risk Assessment in Vietnam: Application Aspect

## Outline

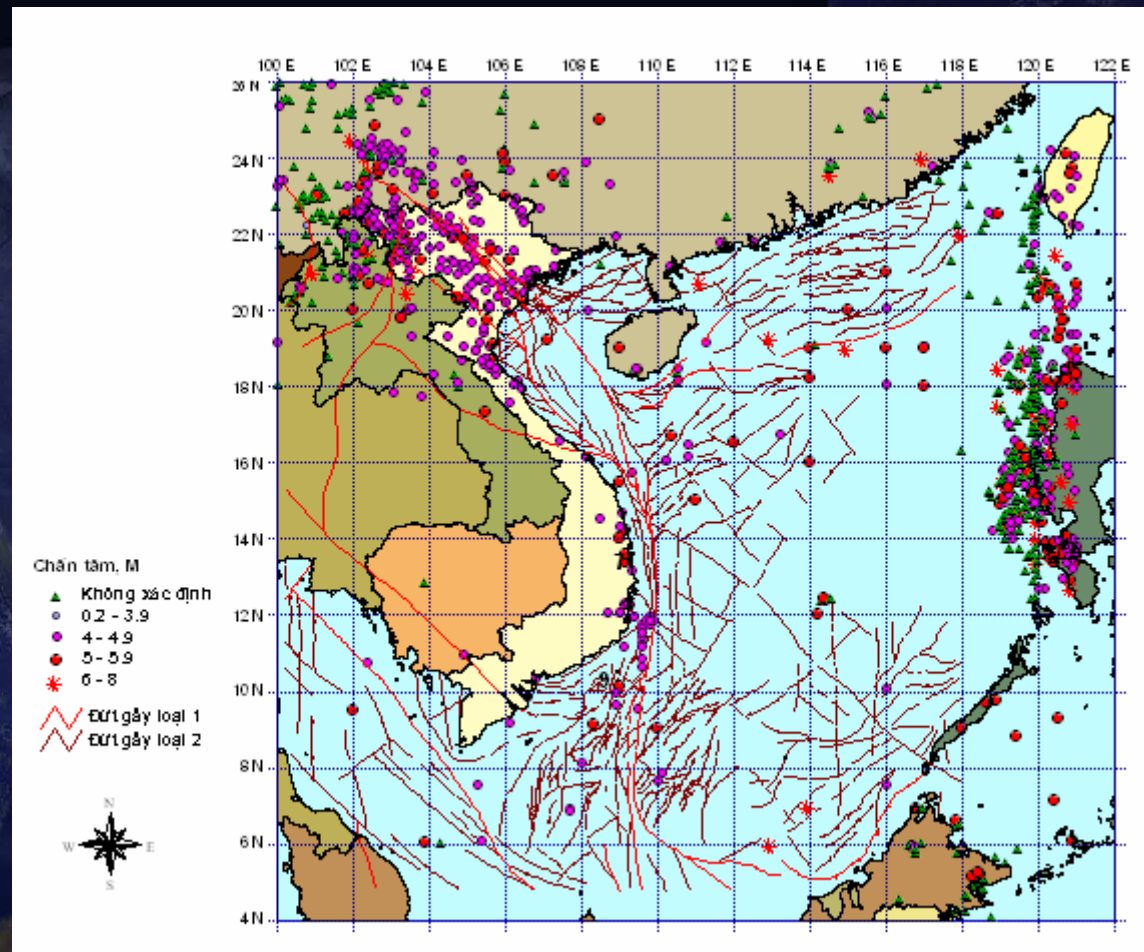
- Introduction
- Earthquake Hazard in Vietnam
- Seismic Hazard Assessment : State of the Art
- Urban Risk Assessment and Loss Estimation
- Application Examples
- Conclusion

## Introduction

A reliable, up-to-date earthquake hazard assessment is an essential tool in national disaster mitigation in the sense that it sets out the appropriate design levels that can ensure safe, cost-effective construction.

In the long term, a national building stock that is appropriately designed will prove a sound investment, in the mitigation of future disaster.

# Earthquake hazard in Vietnam



*Seismotectonic map of Vietnam and adjacent sea areas*

Nguyễn Hằng Ph--ng



# Earthquake hazard in Vietnam

## Seismicity

- The largest earthquakes in country: 3
  - 1 historical (in the 14th century)
  - 2 recorded: Dien Bien 1935 (M=6.7) and Tuan Giao 1983 (M=6.7)
- Offshore volcanic earthquake 1923 (M=6.1).
- Most recent earthquakes on 8th November 2005: 2 (M=5.1 and 5.5) offshore Vung Tau city, South Vietnam
- Many others ...

# Earthquake hazard in Vietnam

## Threat

- A number of large cities and industrial centers are laying in zones, vulnerable to seismic shakings.
- Hanoi, the capital city, is located in the zone of intensity 8 (by MSK scale).
- The biggest in the country Son La hydropower plant might expect shakings of intensity 8-9 in the future.
- Da nang, Dung Quat and several urban areas in Central Vietnam can be affected by 7 intensity shakings.

# Earthquake hazard in Vietnam

## Awareness

- Since all the largest earthquakes have occurred in remote areas, far from the urban and development cities, they were not recognized as the devastating ones.
- Even with the events of magnitude 6.7 or higher observed in Vietnam, **earthquakes have not been considered as a highest priority disaster in the country** until last two year events (the Sumatra tsunami of 26/12/2004 and two offshore earthquakes that shook Ho Chi Minh city in 2005).

# seismic Hazard assessment: State of the art

The four-decade history of earthquake hazard assessment in Vietnam can be divided roughly into two periods, which reflect two different approaches on methodology used: the deterministic and the probabilistic ones.



# seismic Hazard assessment: state of the art

## Deterministic approach

- 1968-1985
- Parameters estimation using deterministic methods
- Seismic zoning maps: North Vietnam (1968), South Vietnam (1980) and entire country (1985, frequently updated).
- In terms of Intensity (MSK-64)
- Based on seismotectonic regionalization
- Both seismic shaking zones and seismogenic zones are depicted
- For each seismic zone, a set of parameters such as expected maximum magnitude  $M_{max}$  and average focal depth  $h$  are indicated.

# seismic Hazard assessment: state of the art

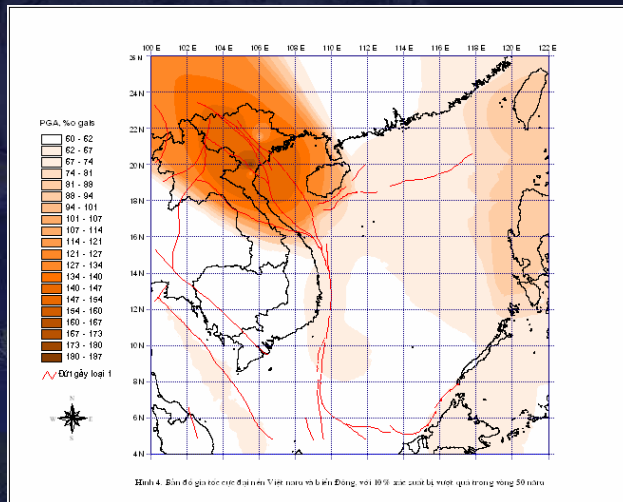
## Probabilistic approach

- 1985 - now
- Hazard parameters estimation: Gumbel's extreme value distributions, maximum likelihood method
- Probabilistic seismic hazard maps: Cornell-McGuire method, EQRISK program
- Mostly in terms of PGA
- Based on seismotectonic regionalization
- First published in 1993, frequently updated (1997, 2003)

# seismic Hazard assessment: state of the art

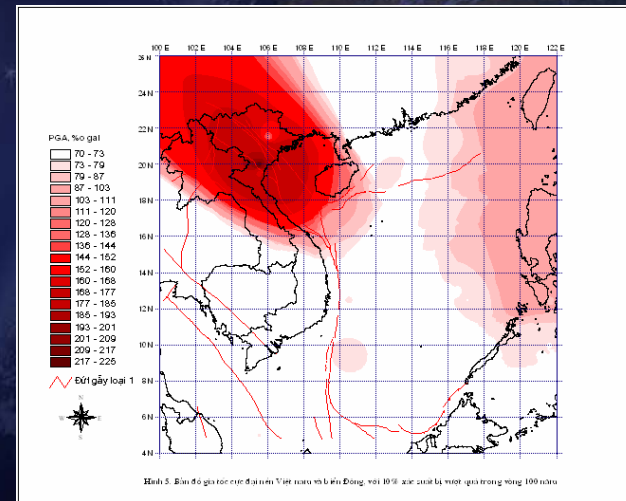
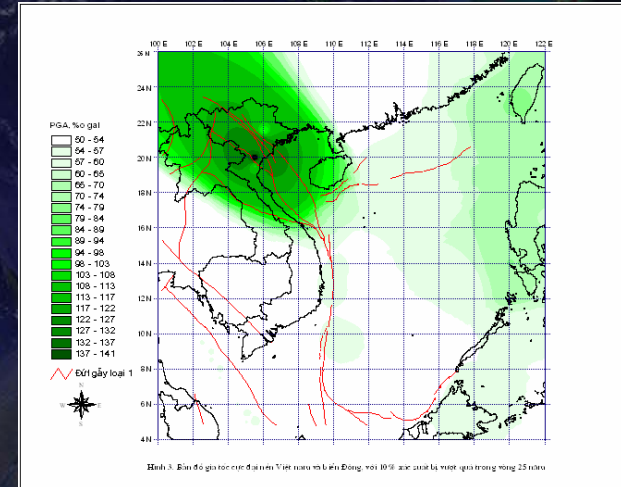
Probabilistic approach

PGA maps:



10% of being exceeded in 50 years

10% of being exceeded in 25 years



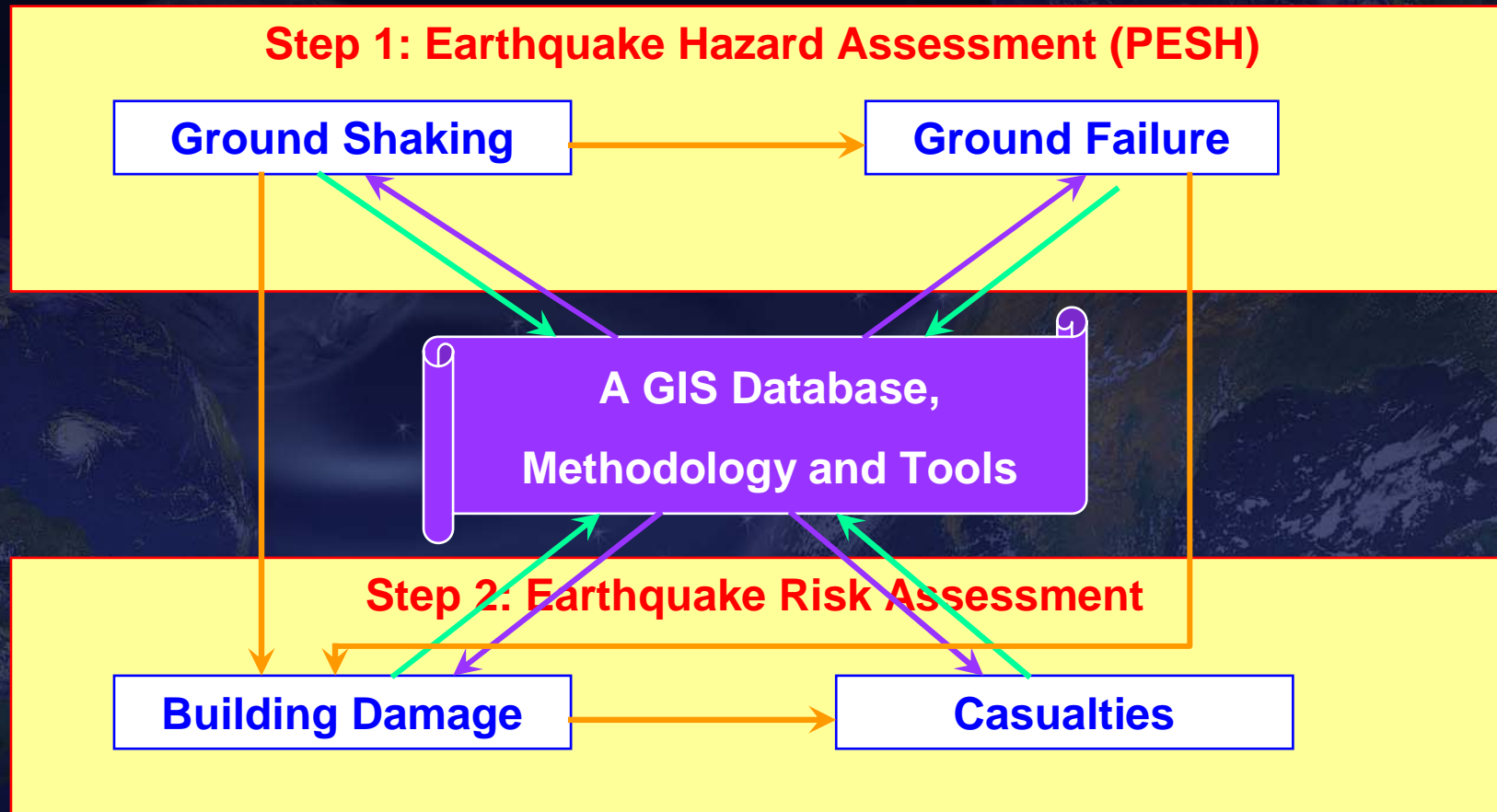
10% of being exceeded in 100 years



# Urban risk assessment and loss estimation

- Starting from 2000s
- Hanoi Projects on urban seismic risk assessment (2000 – 2003, ongoing since 2006), Ho Chi Minh city Project on urban seismic risk assessment (starts 2007)
- Incorporate Seismic hazard and Risk Assessments as two stages of a whole procedure
- Using Geographical Information System (GIS)
- In terms of Decision Support System (DSS)

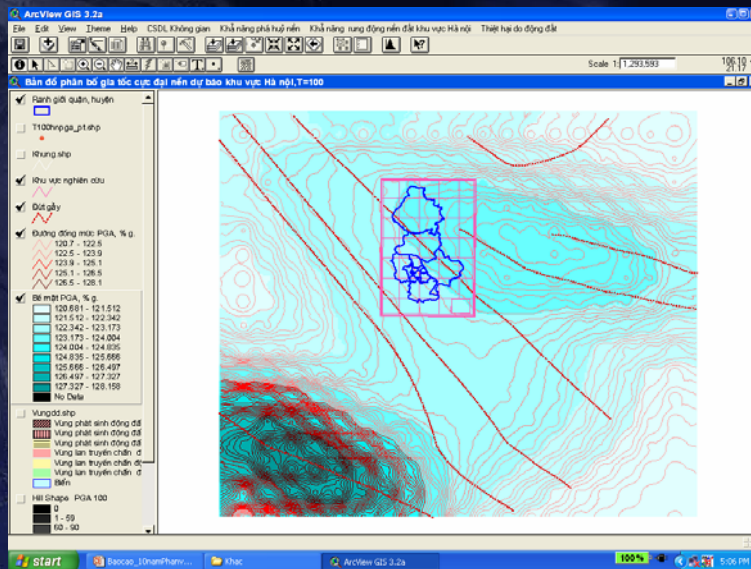
# Urban risk assessment and loss estimation



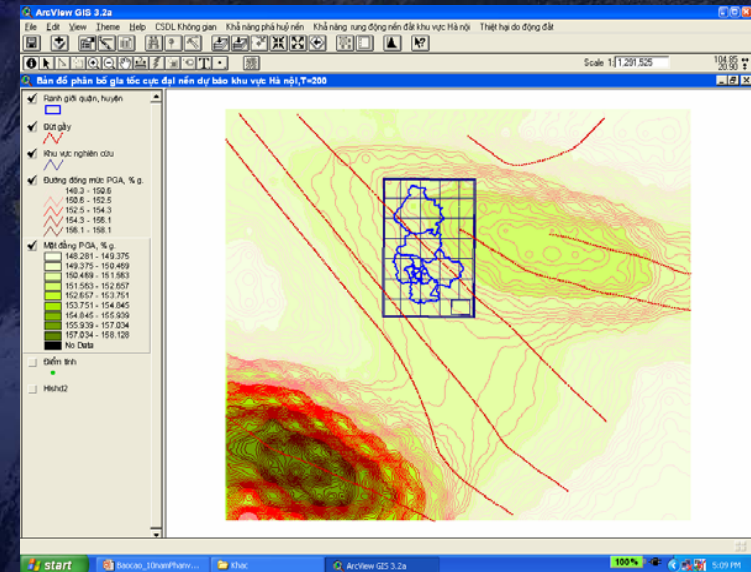
# The Hanoi's case study

## Ground Motion assessment

100 years



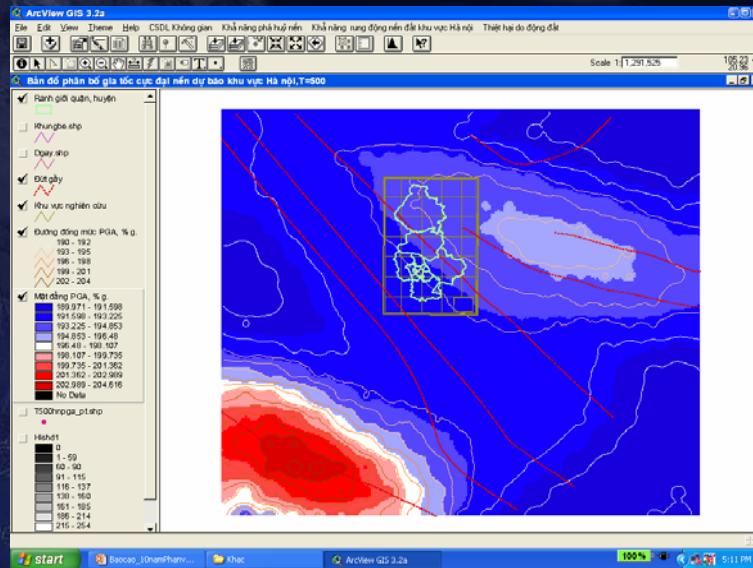
200 years



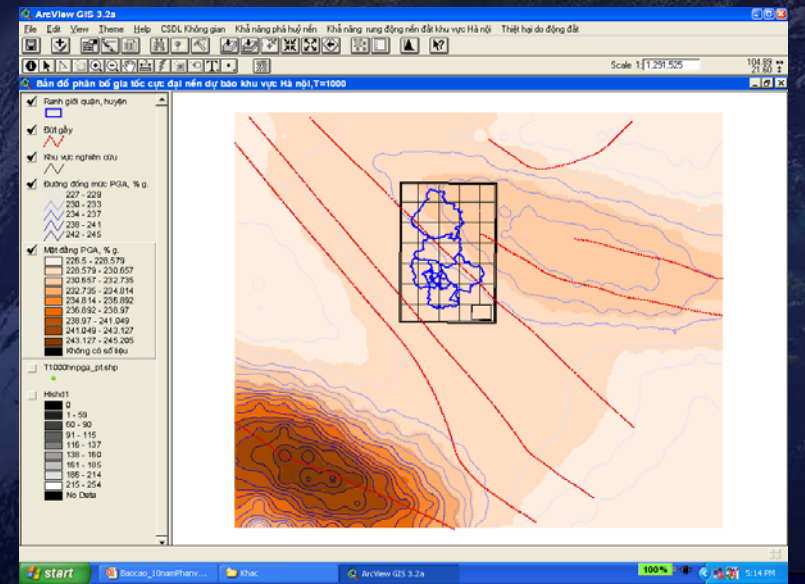
# The Hanoi's case study

## Ground Motion assessment

500 years



1000 years



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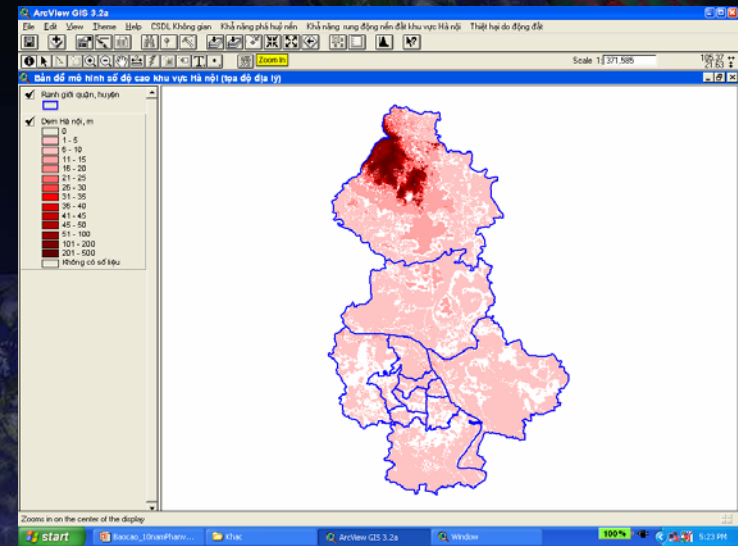
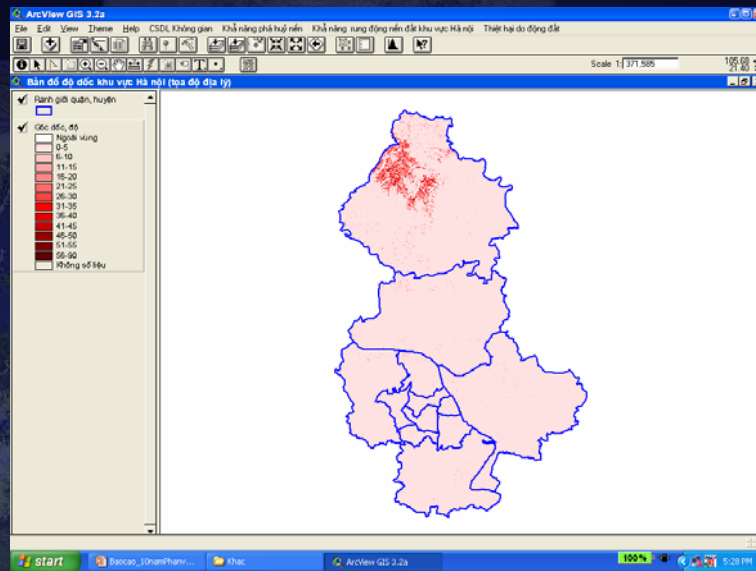


# The Hanoi's case study

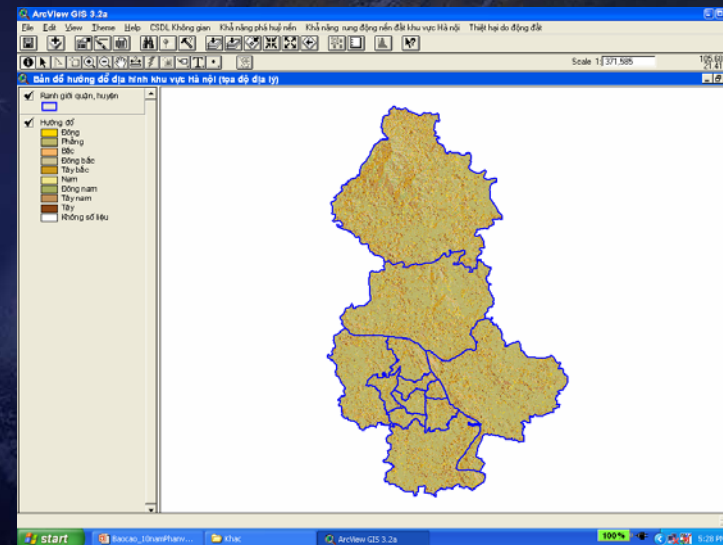
## Ground failure assessment

DEM

Slop map



Aspect map



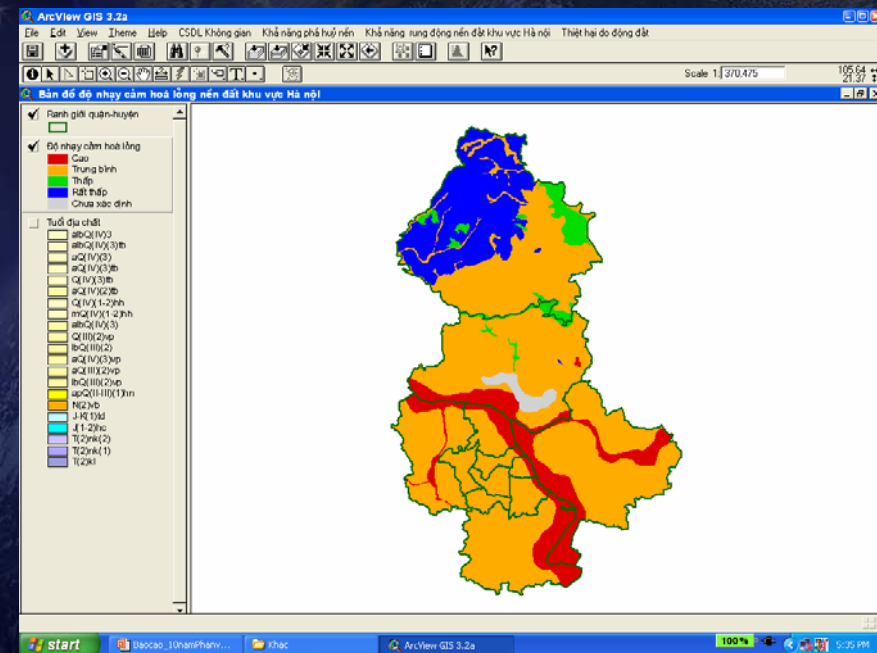
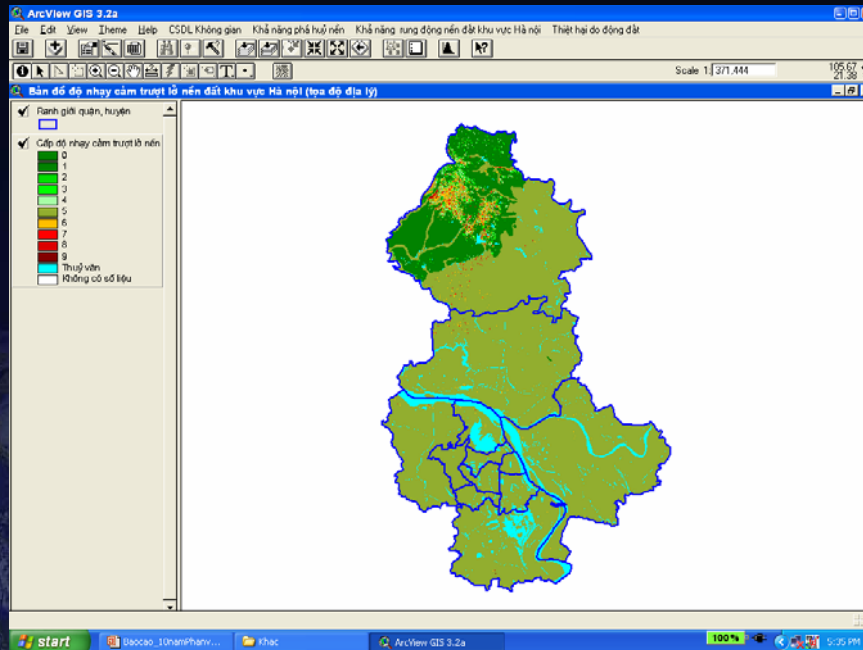


# The Hanoi's case study

## Ground failure assessment

*Landslide susceptibility*

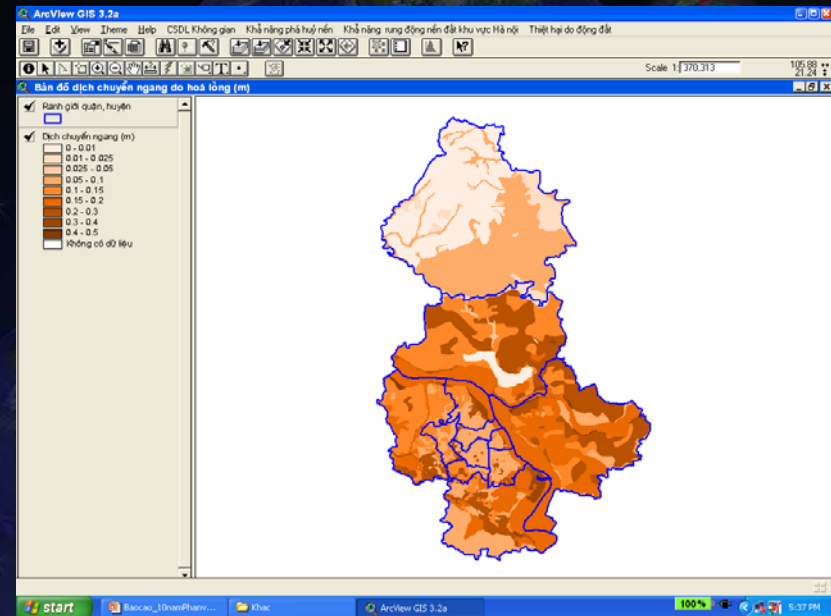
*Liquefaction susceptibility*



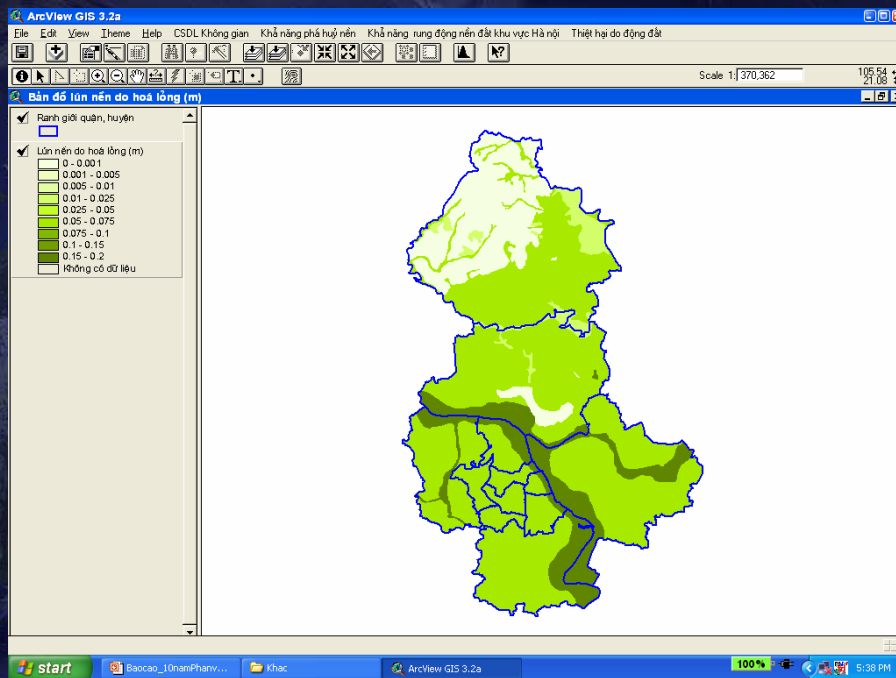
# The Hanoi's case study

## Ground failure assessment

*Ground lateral spreading due to Liquefaction*

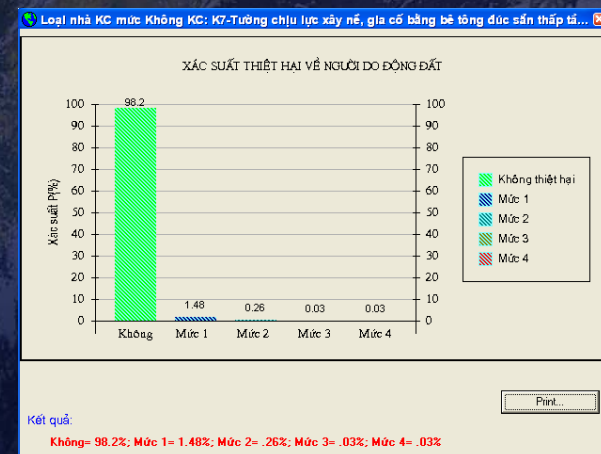
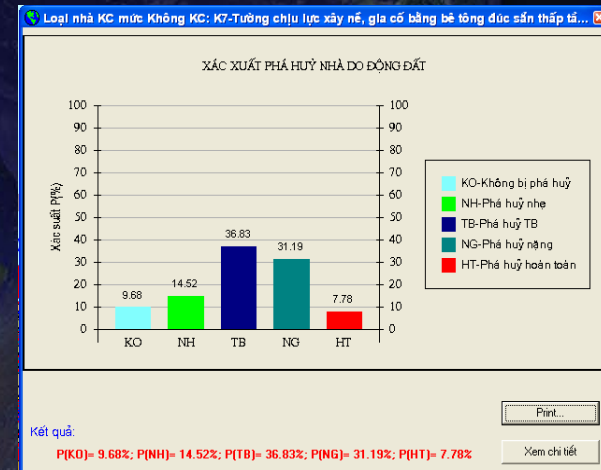
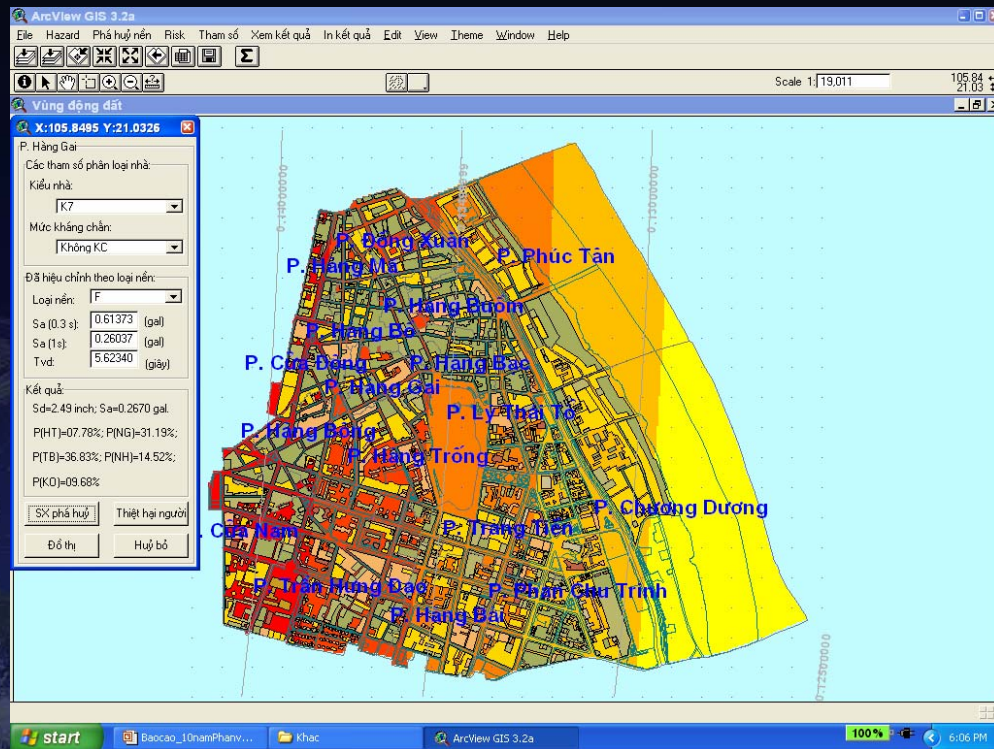


*Ground settlement due to Liquefaction*



# The Hanoi's case study

## Earthquake loss estimation : Hoan Kiem District



*Building damage state probability and Casualties: calculation at points*



## The Hanoi's case study

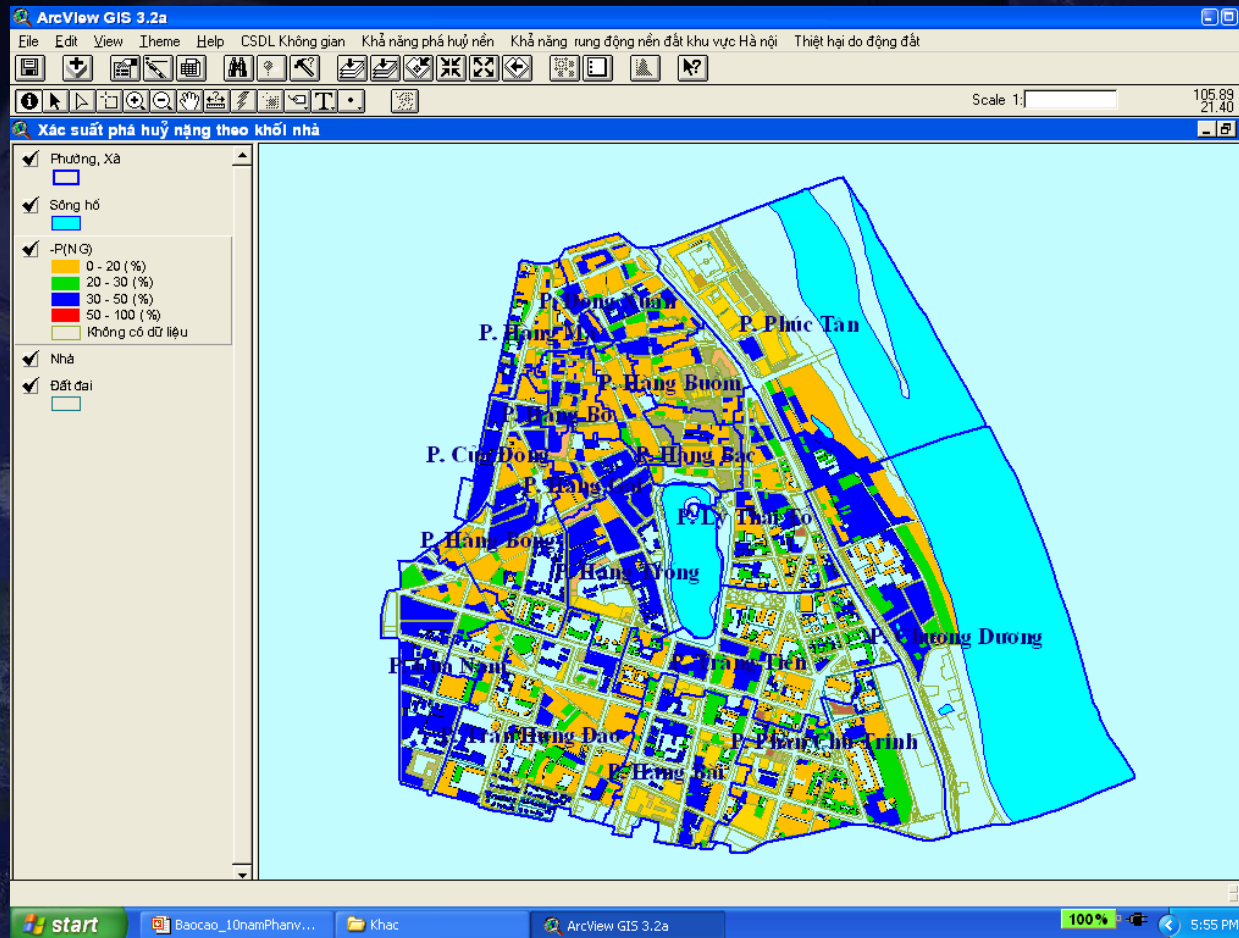
### Building damage : the Hoan Kiem district

- Earthquake scenario
- Building damage is described by five damage states: none, slight, moderate, extensive or complete.



# The Hanoi's case study

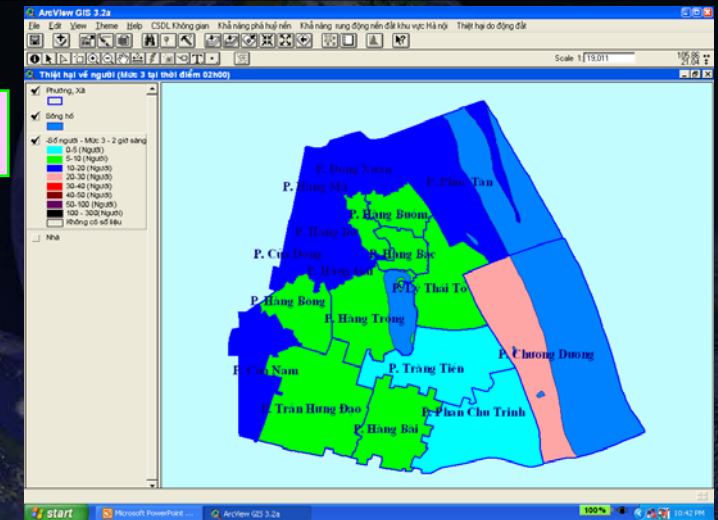
## Building damage : the Hoan Kiem district



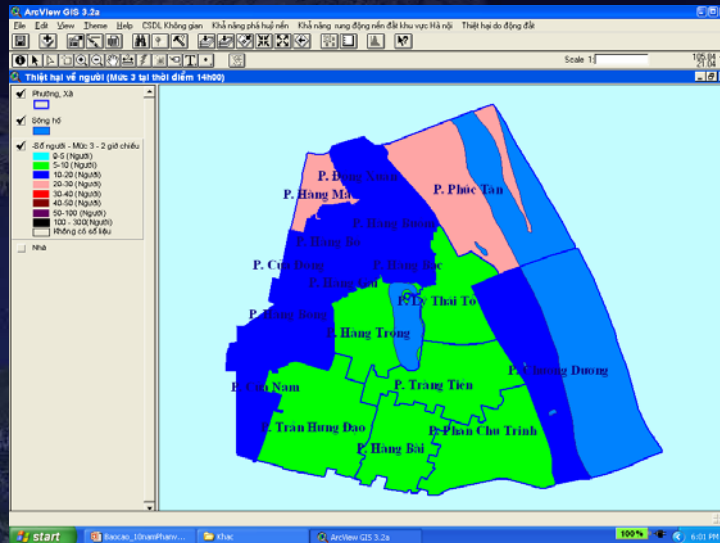
*Mapping the probability of damage states of building stocks: extensive damage*

# The Hanoi's case study

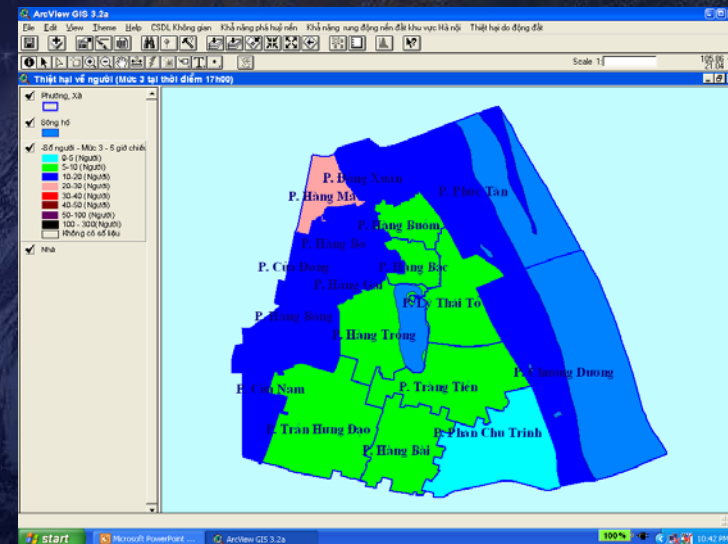
## Casualty estimation (The Hoan Kiem district)



Severity 3, at 2 a.m.



Severity 3, at 2 p.m.



Severity 3, at 5 p.m.

## Application Examples

- **F-Hazard:** a GIS-based tool for Deterministic Seismic Hazard Assessment, using a Fault Source Model
- **ArcRisk:** a GIS-based DSS, a powerful tool for Urban Seismic Risk Assessment and Loss Estimation.

# Application Examples: F-hazard

## Magnitude-fault parameter relationship

- Wells and Coppersmith Formula (1994):

$$\text{Log}_{10}(L) = a + b \cdot M$$

where L is the fault rupture length, km; M is the Moment Magnitude of the earthquake; a and b: empirical coefficients

Regression Coefficients of Fault Rupture Relationship of Wells and Coppersmith (1994)

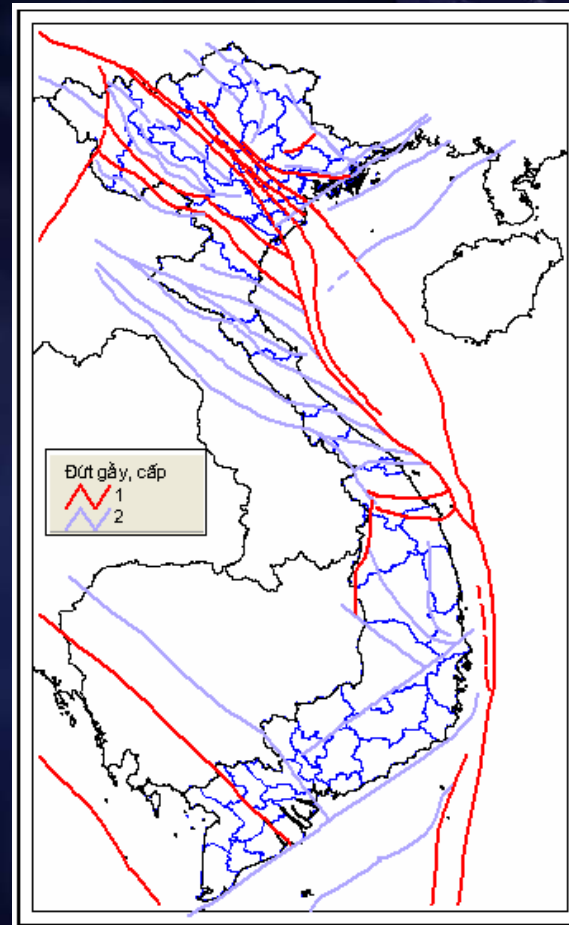
Rupture Type	Fault Type	a	b
Surface	Strike Slip	-3.55	0.74
	Reverse	-2.86	0.63
	All	-3.22	0.69
Subsurface	Strike Slip	-2.57	0.62
	Reverse	-2.42	0.58
	All	-2.44	0.59



# Application Examples: F-hazard

## Database of Seismically Active Fault systems

- 46 faults systems, capable of originating earthquakes



## Application Examples: F-hazard

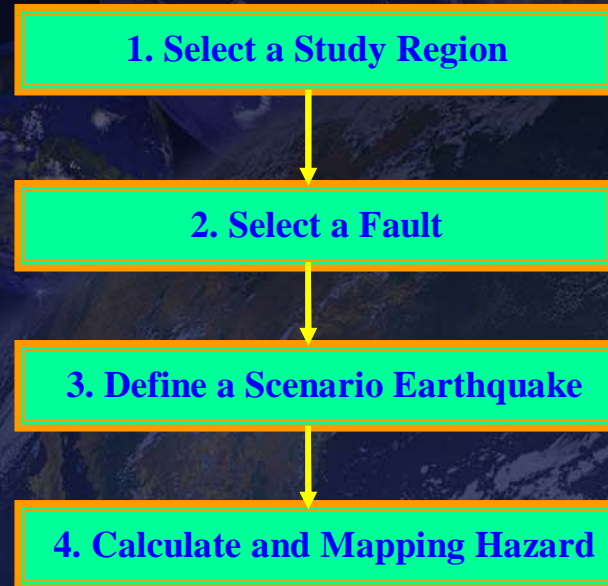
### Attenuation relationship

- Nguyen Dinh Xuyen et al. (1999)
- Xiang Jianguang and Gao Dong (1994)
- Cambell and Bozorgnia (1994)
- Youngs, Chiou, Silva and Humphrey (1997)
- Boore, Joyner and Fumal (1993, 1994)
- Munson and Thurber (1997): Hawaii earthquakes.
- Sadigh, Chang, Abrahamson, Chiou and Power (1993)
- Frankel et al (1996)
- Toro, Abrahamson and Schneider (1997)
- Lawrence Livermore National Laboratory (Savy, 1998)

# Application Examples: F-hazard

Tool

- Name : F-Hazard
- Environment: ArcView GIS
- Programming language: Avenue

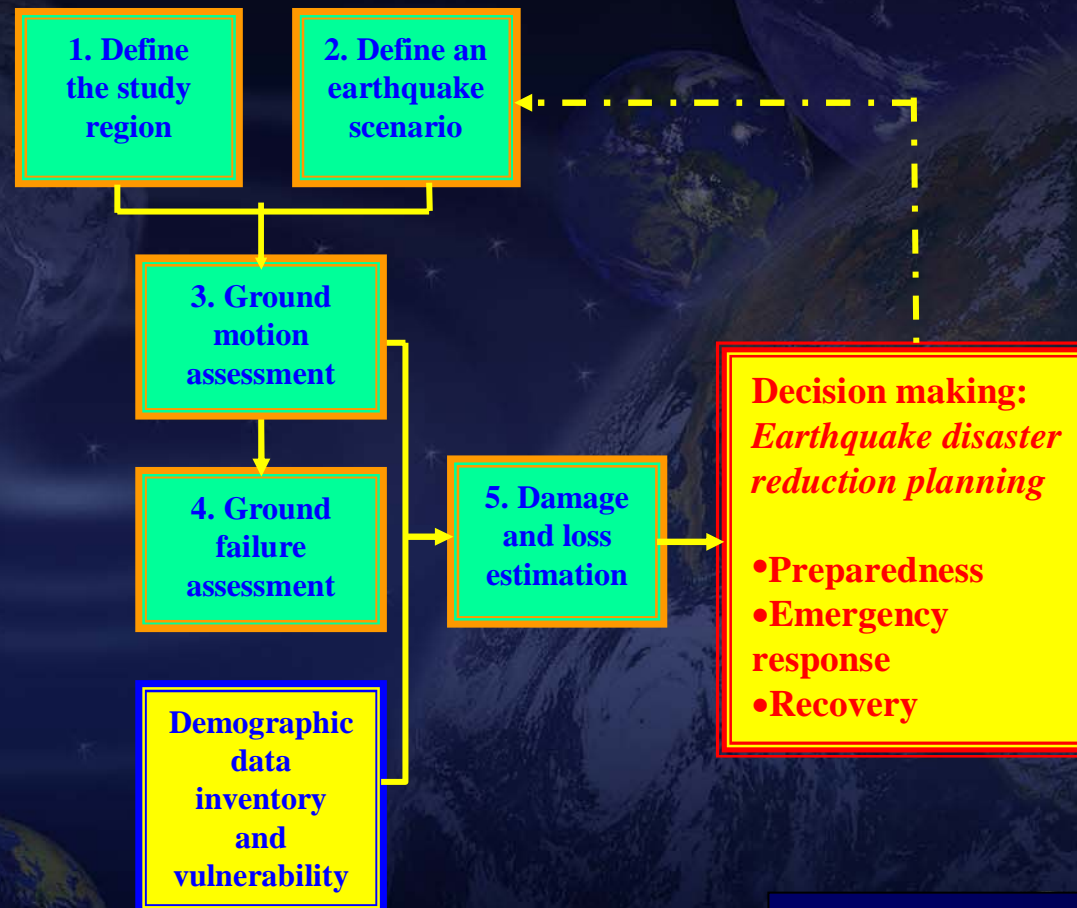


## Application Examples: Arcrisk

- **ArcRisk**: a GIS-based software, a powerful tool for earthquake hazard and risk assessment.
- **Environment**: ArcView GIS
- **Programming language**: Avenue
- **Two main components of ArcRisk** : 1) **Earthquake hazard assessment** (Ground motion and ground failure) and 2) **Earthquake Risk assessment** (Estimation of Building damage and casualties due to earthquake)
- More important is the function of *ArcRisk* as a **Decision Support System**, which enables users to anticipate the consequences of future earthquakes and to develop plans and strategies for reducing risk. This forecasting capability makes *ArcRisk* useful for many users with different needs.

# Application Examples: Arcrisk

A DSS



## Conclusion

Probably, it's the time for Vietnam to start with the NeoDeterministic approach of Seismic Hazard and Seismic Risk Assessment ?...

# Seismic Hazard and Risk Assessment in Vietnam: Application Aspect

## Thank you!