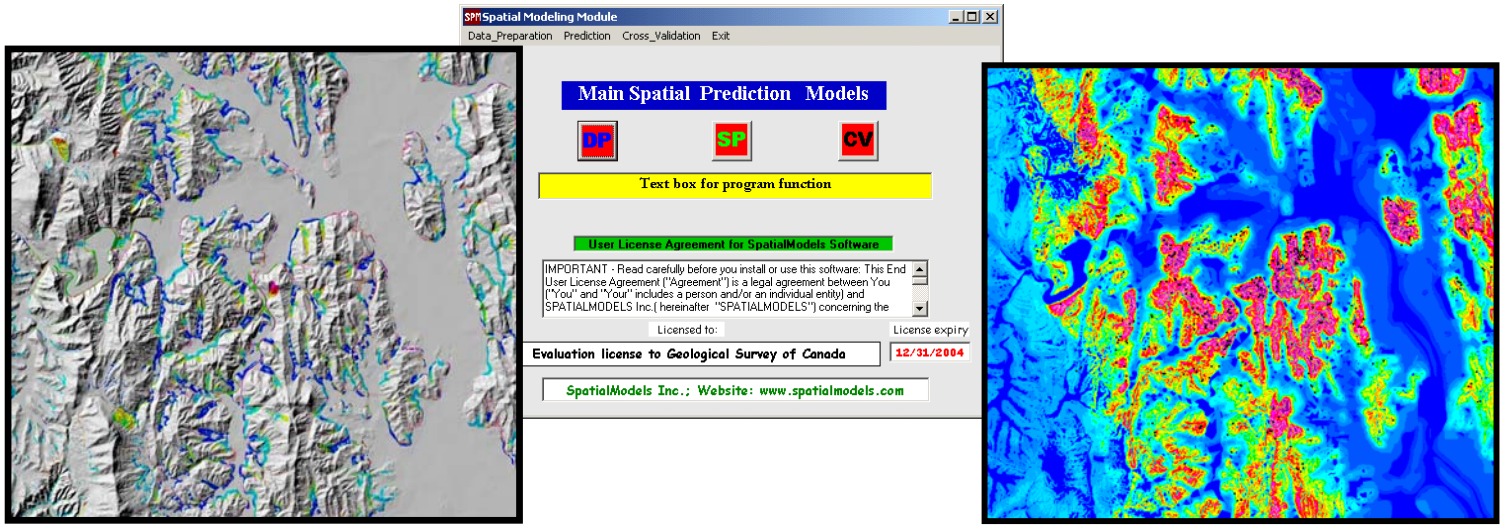
risk spm hazard



Risk Assessment Using Spatial Prediction Models for Natural Disaster Preparedness

Chang-Jo F. Chung[1], Andrea G. Fabbri[2,3], Dong-Ho Jang[4], Henk J. Scholten[2]

[1]Geological Survey of canada, Ottawa, Canada

[2]SPIN*lab*, Vrije Universiteit, The Netherlands

[3]DISAT, University of Milano-Bicocca, Italy

[4]Gong-Ju National University, Gong-Ju, Korea

Topics

- Risk terms & motivation
- Application in South Korea: from Risk down to Hazard
- Risk visualization: Population and Infrastructure risk maps
- 3-stage approach to spatial prediction: Prediction-rate curves and landslide hazard map
- Software tools for risk analysis

Risks and motivation

- **Risk analysis**: quantification of probabilities and expected consequences of identified risks
- **Risk evaluation**: sociopolitical and moral-ethical component … judging significance & acceptability
- **Risk management**: activity for reducing unacceptably high risks; combines analysis & evaluation
- Here, ***spatial risk assessment***: methods of generating risk maps with the different levels of relative risk represented for the above risks, either natural or technological …

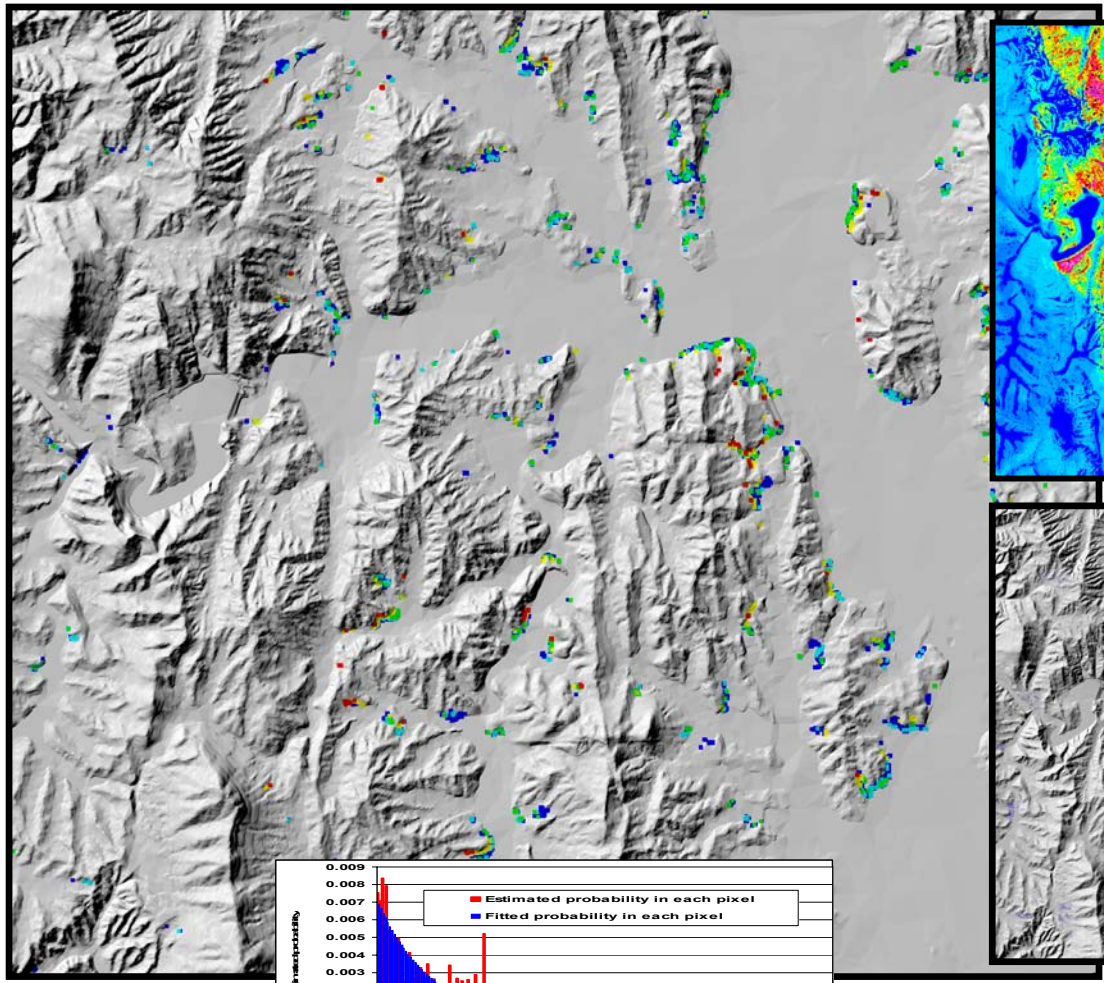
- Many examples exist of **risk maps** of landslide hazard to zone the territory into classes of risk levels (r. to life, to assets, to economy, …). Without such maps, natural risk management is **unfeasible**.
- Most risk maps available or produced to date, seem to represent only:
  - ☞ **qualitative classes**,
  - ☞ **past events** and
  - ☞ **omit uncertainty** …

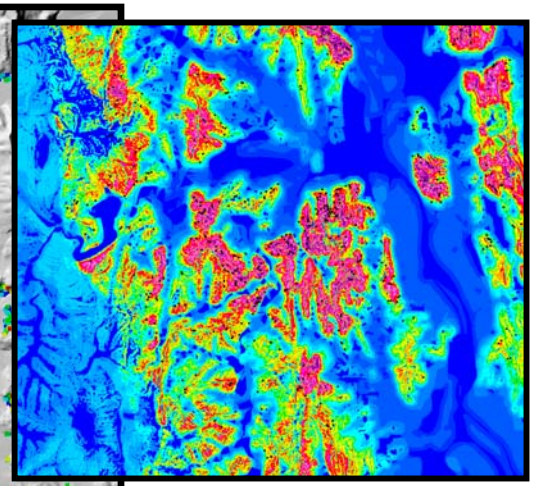
Reasons for impasse of H/R prediction maps

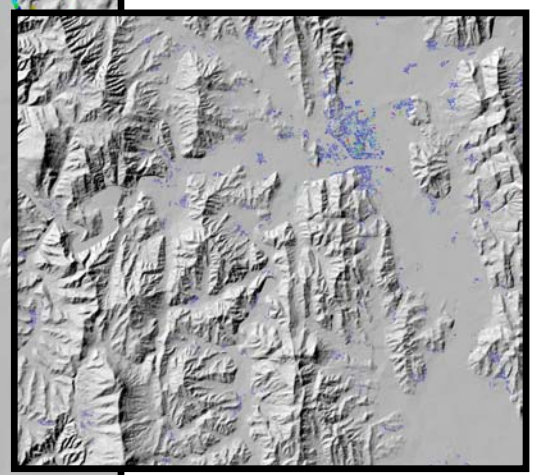
- Most maps have limitations that make them unusable to decision makers
- Current maps are hiding facts or fail to use systematic evaluations
- Refusal to release spatial estimates of Hazard & Risk and associated certainty
- Fear of social impact & consequent misunderstandings
- Ignorance of laymen, of "electorate" who cannot force transparency on D-M
- Lack of responsible management by prevention/mitigation … *only after disaster action starts* … !

Population risk map(5m*5m): estimated total casualties = 3

333,697.730 m N







LEGEND

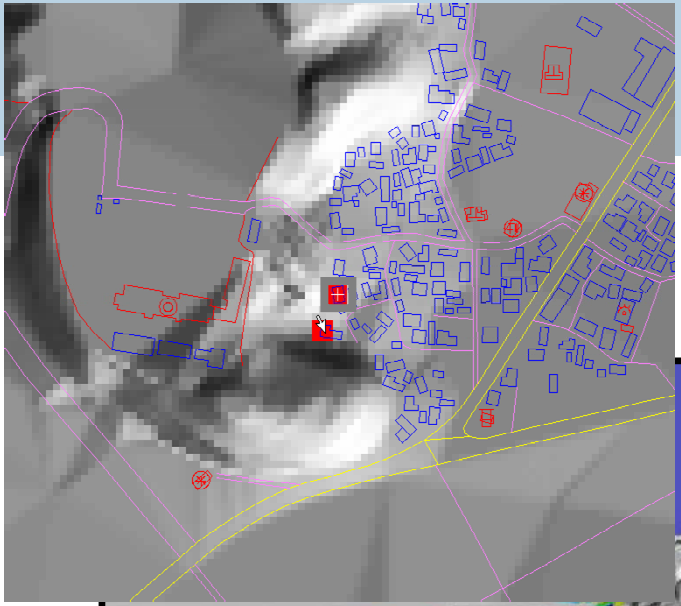
- 1/100
- 5/1,000
- 5/10,000
- 2/10,000
- less 1/10,000

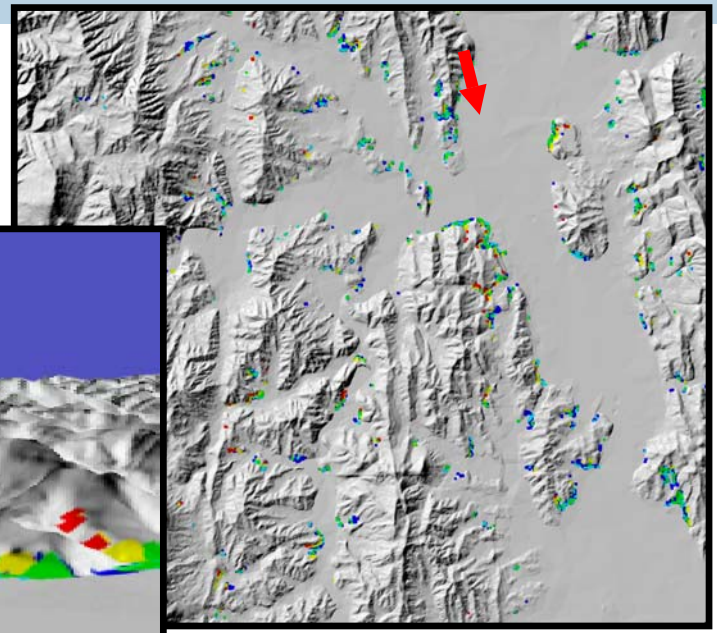
326,477.730 m N

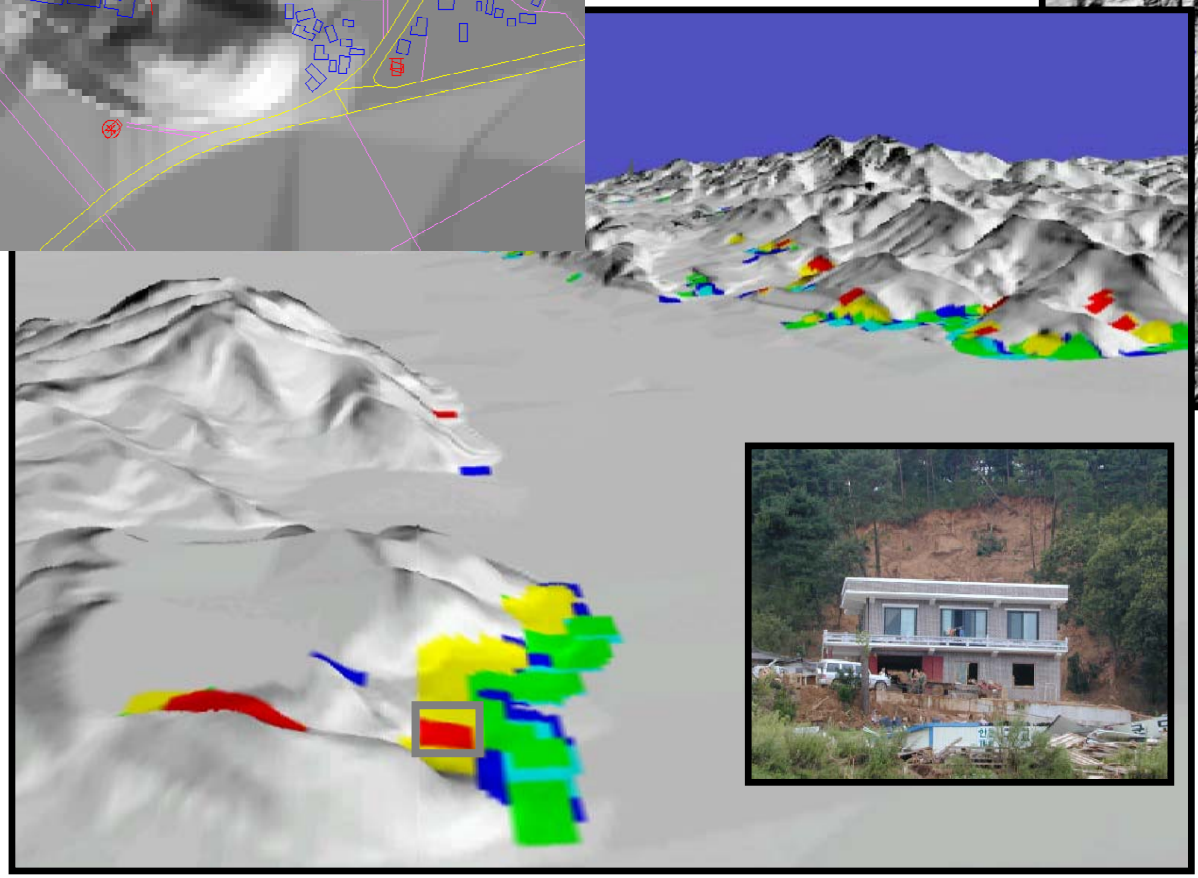
258,810.487 m E

266,930.487 m E

Population risk map(5m*5m): estimated total casualties = 3





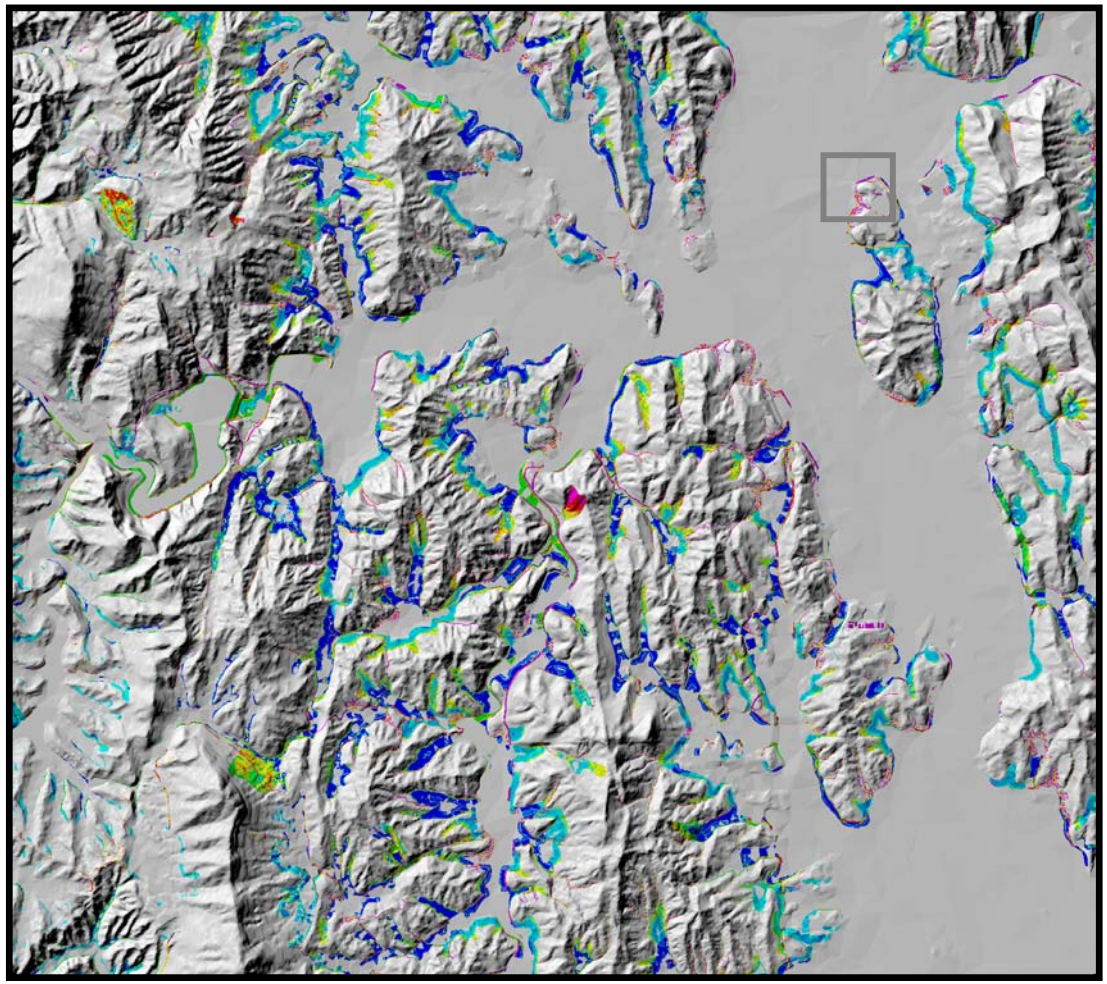


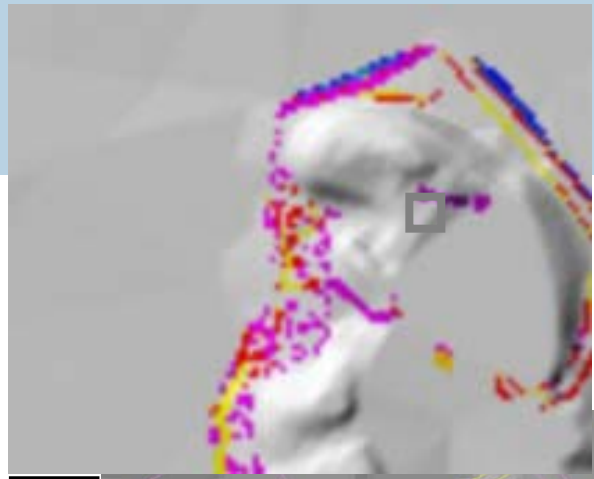
LEGEND

- 1/100
- 5/1,000
- 5/10,000
- 2/10,000
- less 1/10,000

Risk assessment of man-made infrastructures: estimated property damages = $200,000

333,697.730 m N

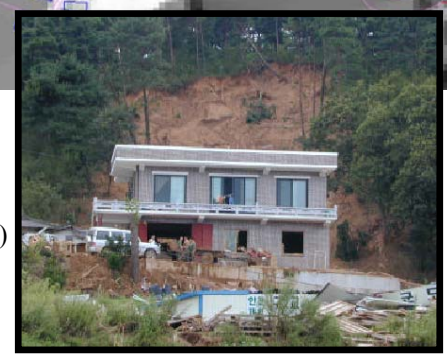




less one $

4

(US : $)

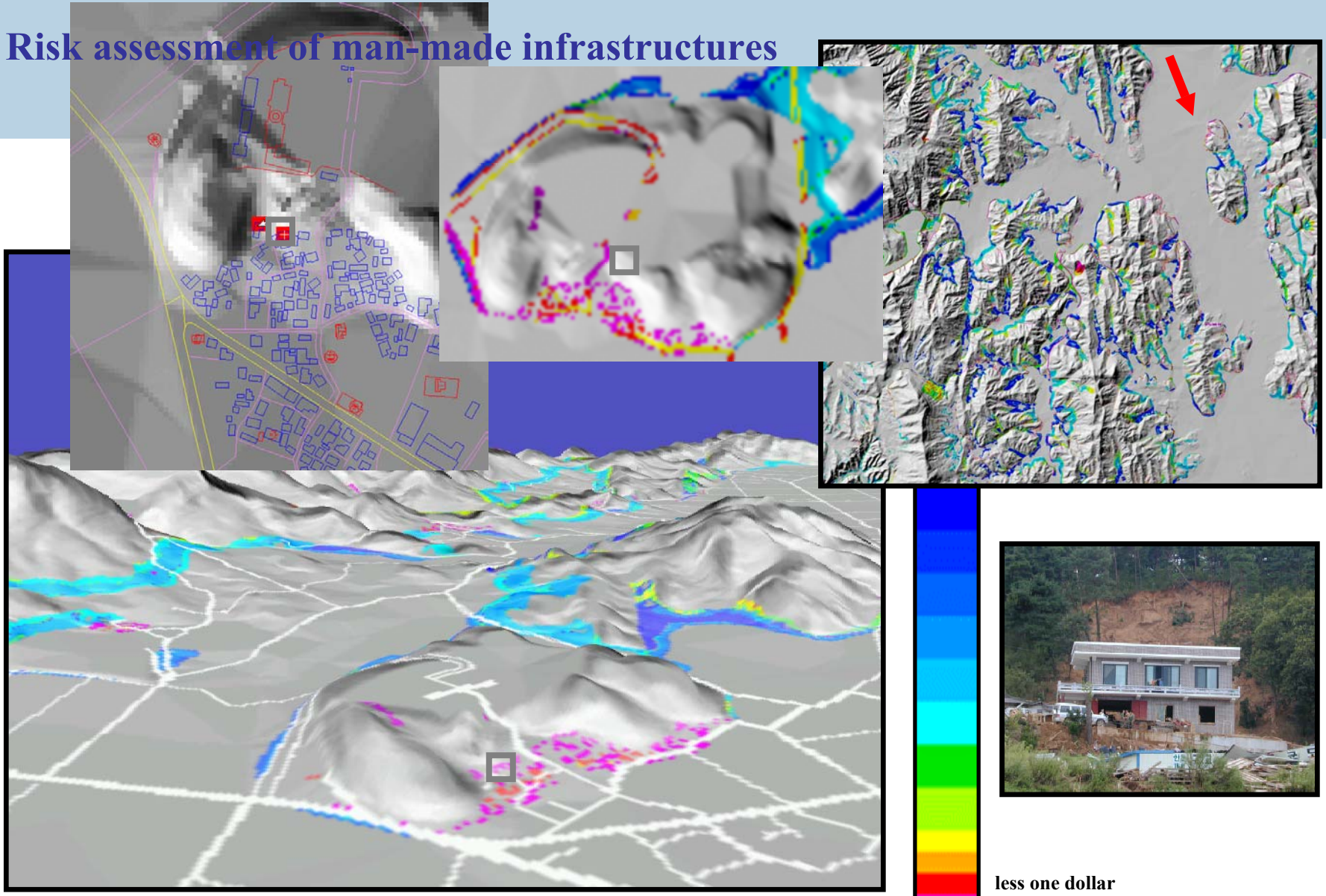


326,477.730 m N

258,810.487 m E

266,930.487 m E

Risk assessment of man-made infrastructures



less one dollar

4

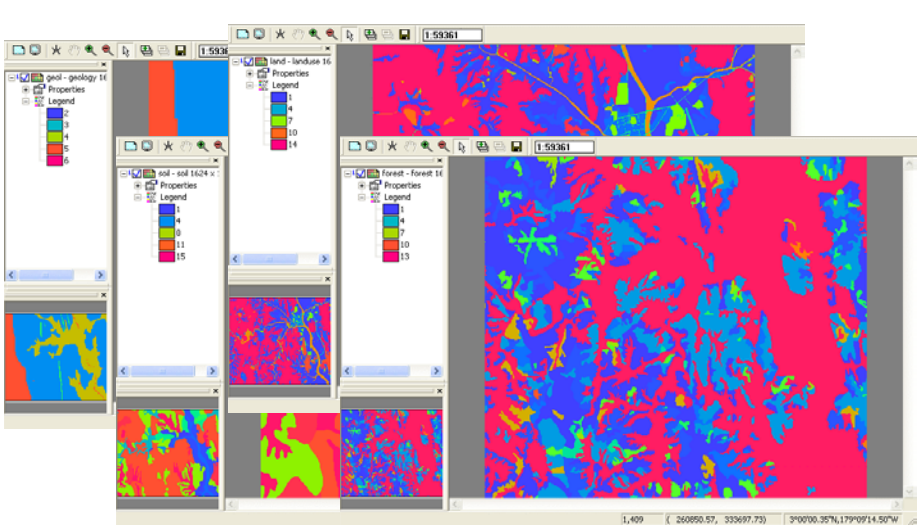
(US : $)

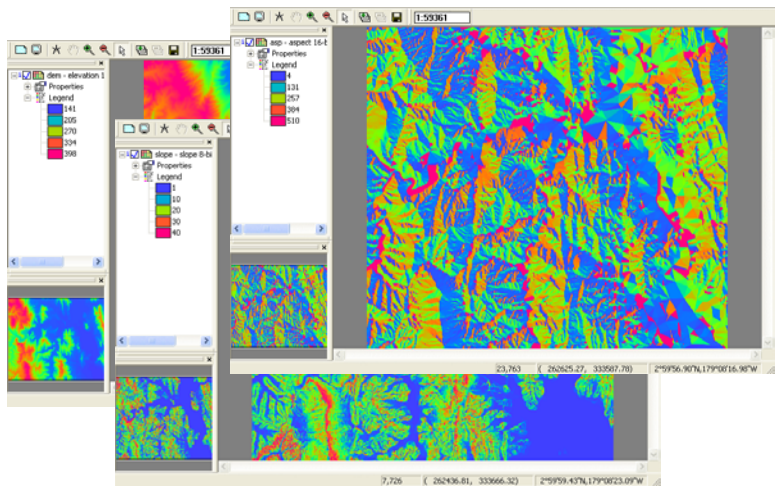
Example: Boeun Area, Korea

Cooperation with Gong-Ju National University, Gong-Ju, Korea

The study area consists of 58.4 km^2 with 45,600 people in 15,000 households. We have surficial geology, forest coverage, land-use, drainage, DEM, and the 420 past surficial debris flow landslides in the area in year 1997.

In 1998 44 new landslides occurred causing 3.3 Million $ damage and 3 casualties.





Socio-economic indicators: Boeun Area, Korea

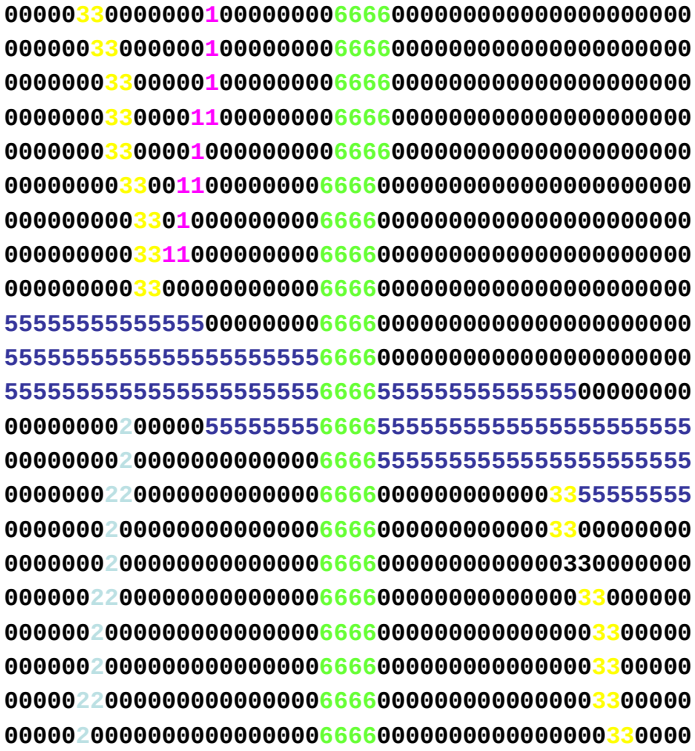
1. **Distribution of population and density**

2. **Distribution of road-networks (paved road: $8,000/5m, unpaved road: $4,000/5m), houses (average costs: $22,500), industrial infrastructures ($6,000/pixel) , farm infrastructures ($3,300/pixel), business infrastructures ($56,300/pixel).**

3. **Distribution of drainage patterns (embankment: $140,000/5m, river bank 1st grade: $5,300/5m, 2nd grade: $3,200/5m, and etc)**

4. **Distribution of forest and land-use (forest: $1,800/pixel, pasture: $90/pixel, orchard: $60/pixel, dry field: $40/pixel, paddy field: $13/pixel)**

Example: Road network infrastructure data layer with two accompanying tables containing $-values and vulnerability for risk assessment



Property values

	Code	value/m	vulnerability
Country road	1	$100	1
2-lane local unpaved rd	2	$500	0.8
2-lane pave highway	3	$2000	0.6
4-lane highway	4	$5000	0.6
4-lane super highway	5	$8000	0.4
4-lane toll highway	6	$10000	0.12
8-lane toll highway	7	$20000	0.12

Economic damage/2-day interruption

	Code	value/m	vulnerability
Country road	1	$0.2	1
2-lane local unpaved rd	2	$1	0.6
2-lane pave highway	3	$9	0.5
4-lane highway	4	$30	0.5
4-lane super highway	5	$500	0.4
4-lane toll highway	6	$1,000	0.1
8-lane toll highway	7	$2,500	0.1

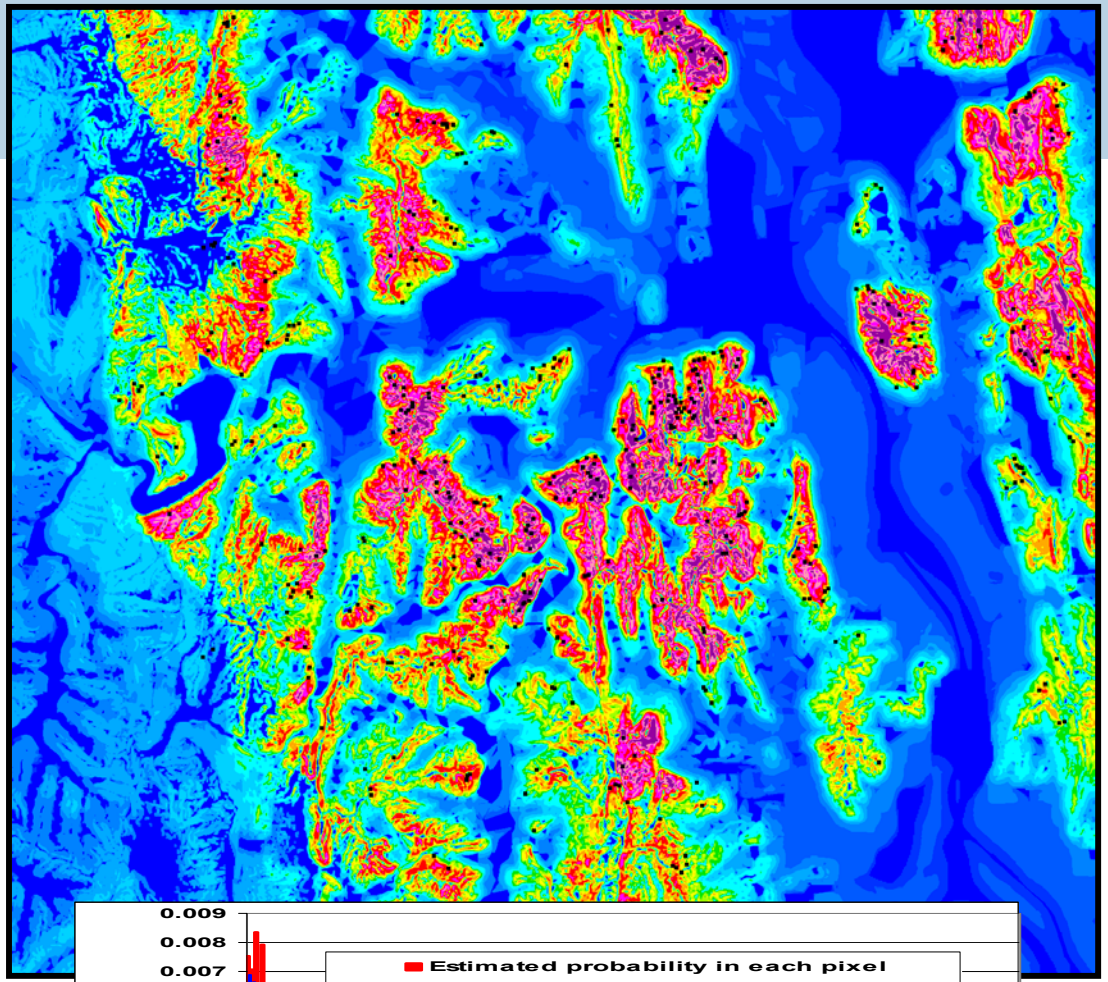
$ in unit of 1000

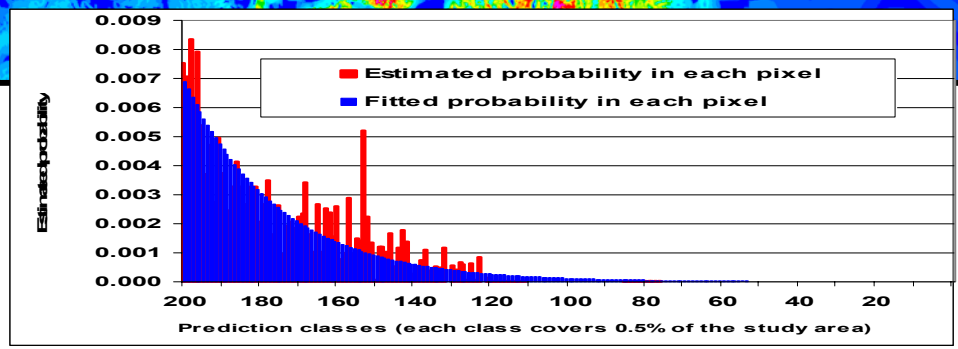
Every socio-economic data layer is accompanied by one or two tables containing economic values (E) and vulnerability (V) for R = E V H except for the population density data layer where E is set to 1.

Year 1997, landslide prediction map, Boeun Area, Korea

- 420 past landslides
- DEM, surficial geology, drainage, and forest coverage
- Likelihood ratio model
- We are now combining the estimated probability and the prediction map with socio-economic data layers to test the effectiveness of risk assessment by comparing 1998 landslides.

- We assume that 2000 pixels will be damaged by landslides in 1998.

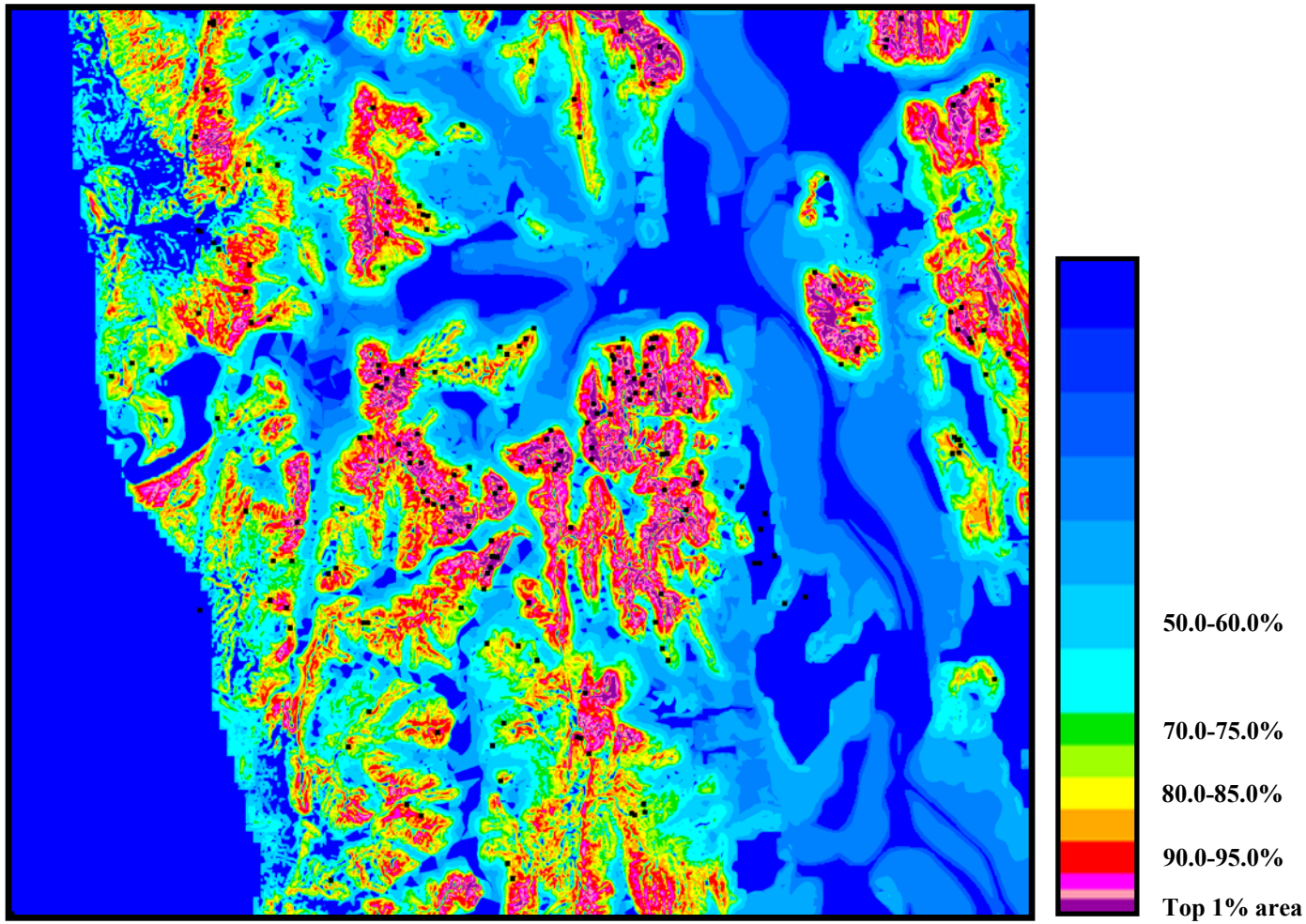




Using only 210 (randomly selected) landslides to generate the landslide susceptibility prediction map, Boeun area,Korea

- 210 past landslides
- DEM, surficial geology, drainage, and forest coverage
- 58.4 sq km
- 5m x 5m resolution
- surficial debris flows
- likelihood ratio model

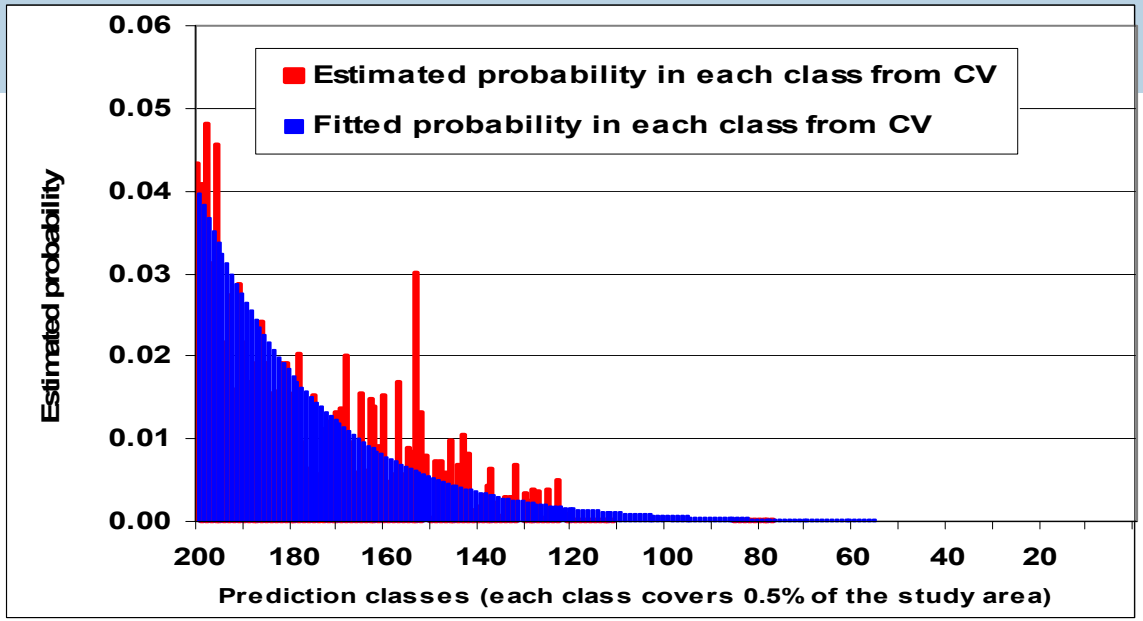
- This prediction map will be compared with the other 210 landslides, not used in constructing the map. The comparison will generate a measure of the validation of the prediction map.

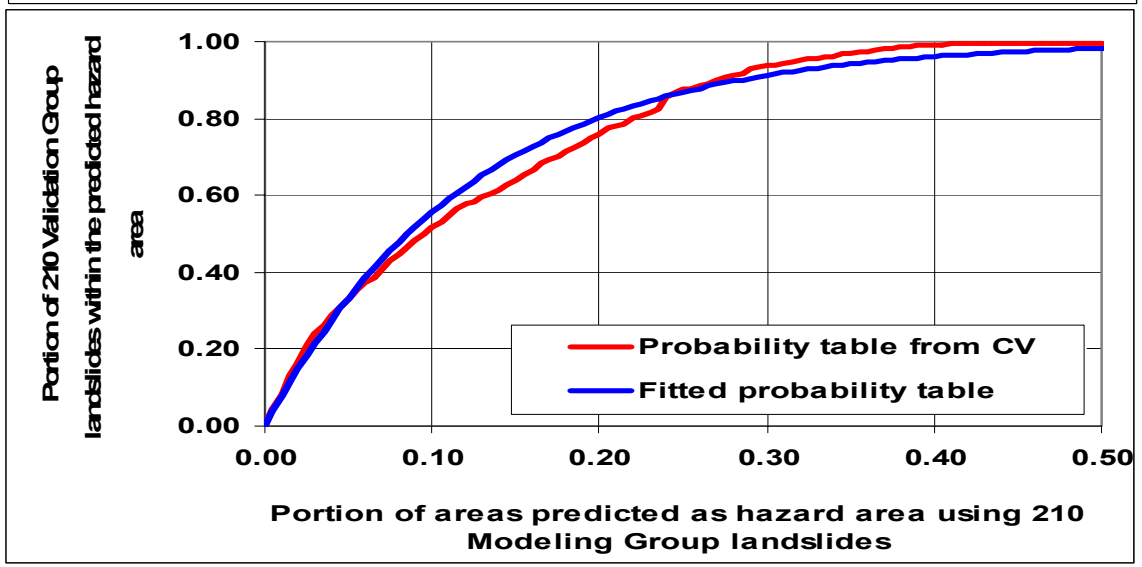


Prediction rate table for each class, Boeun Area, Korea

Year 1997

- Combining the prediction map with the "prediction rate curve" generated by comparing the CV procedure, we can estimate the conditional probability of the occurrences of future landslides in each prediction class.
- We are now almost ready to integrate the socio-economic data layers for risk analysis





Year 1997

- **ASSUMPTION that we are making for the risk assessment for 1998 is that the # of pixels to be affected in 1998 = 2000**

1. **Under the assumption, our risk estimates: Total number of casualties = 3**
2. **Total $ values of property damages = US $3. 5 Million ($ 0.2 Million for man-made structures and $ 3.3 Million for forest damages)**

- **FACT:**

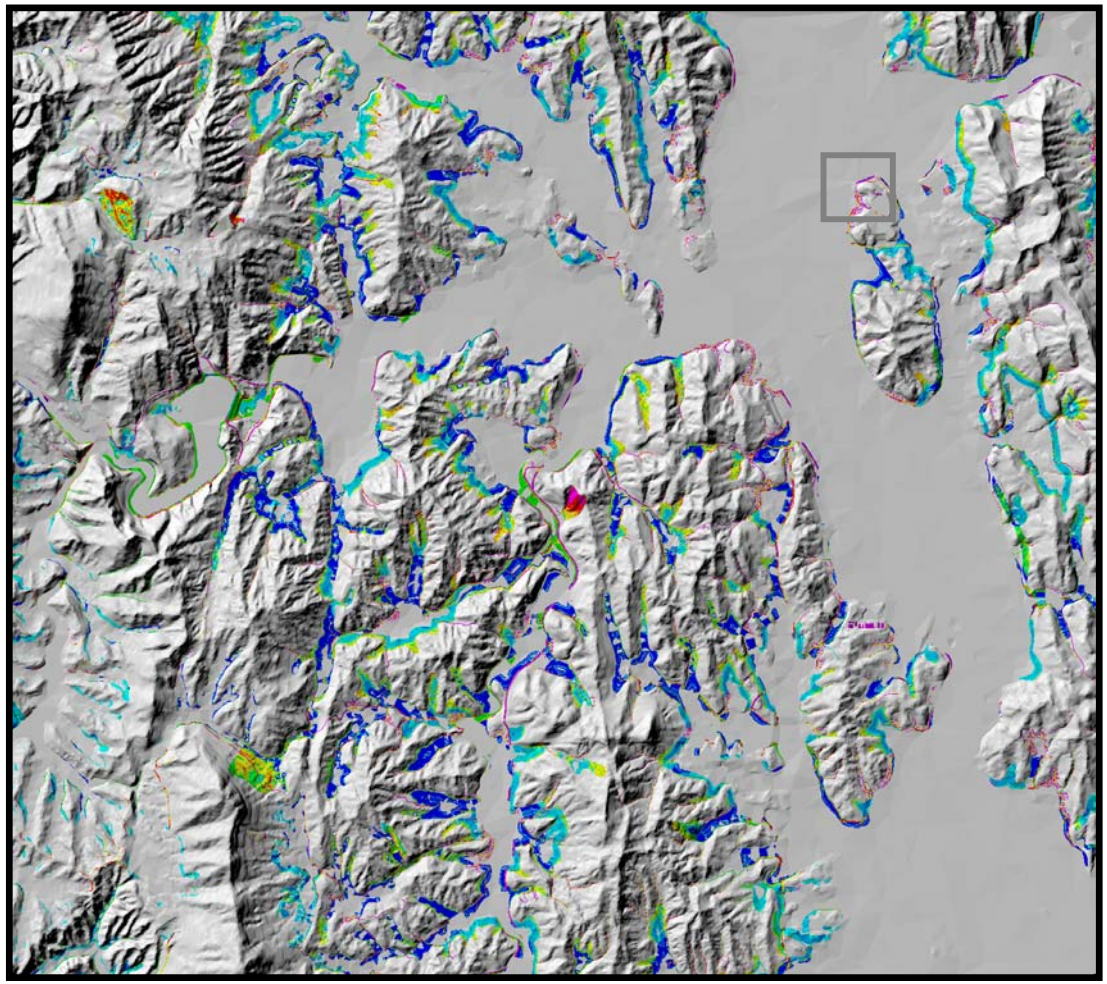
  In 1998, there were 44 landslides (approximately 2000 pixels) with 3 casualties and US $3. 3 Million property damages.
- **QUESTION:**

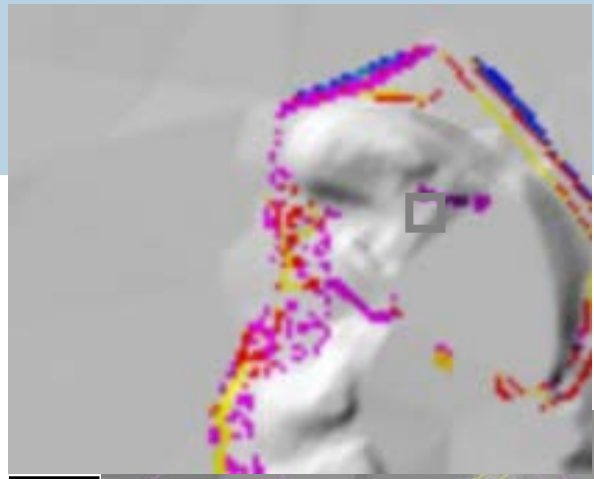
  What will happen to the estimates if we assume that 4000 pixels will be damaged in year 1998 (because of climate changes or other reasons)?
- **CONSIDERATION:**

  We can easily repeat the computation under the new assumption …

Risk assessment of man-made infrastructures: estimated property damages = $200,000

333,697.730 m N

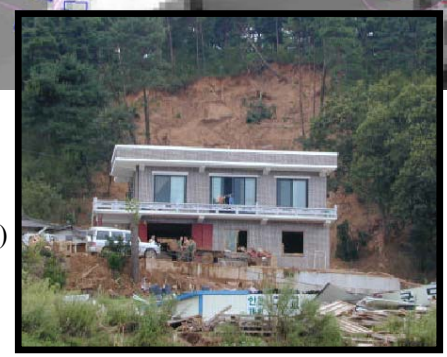




less one $

4

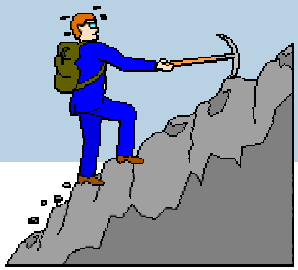
(US : $)



326,477.730 m N

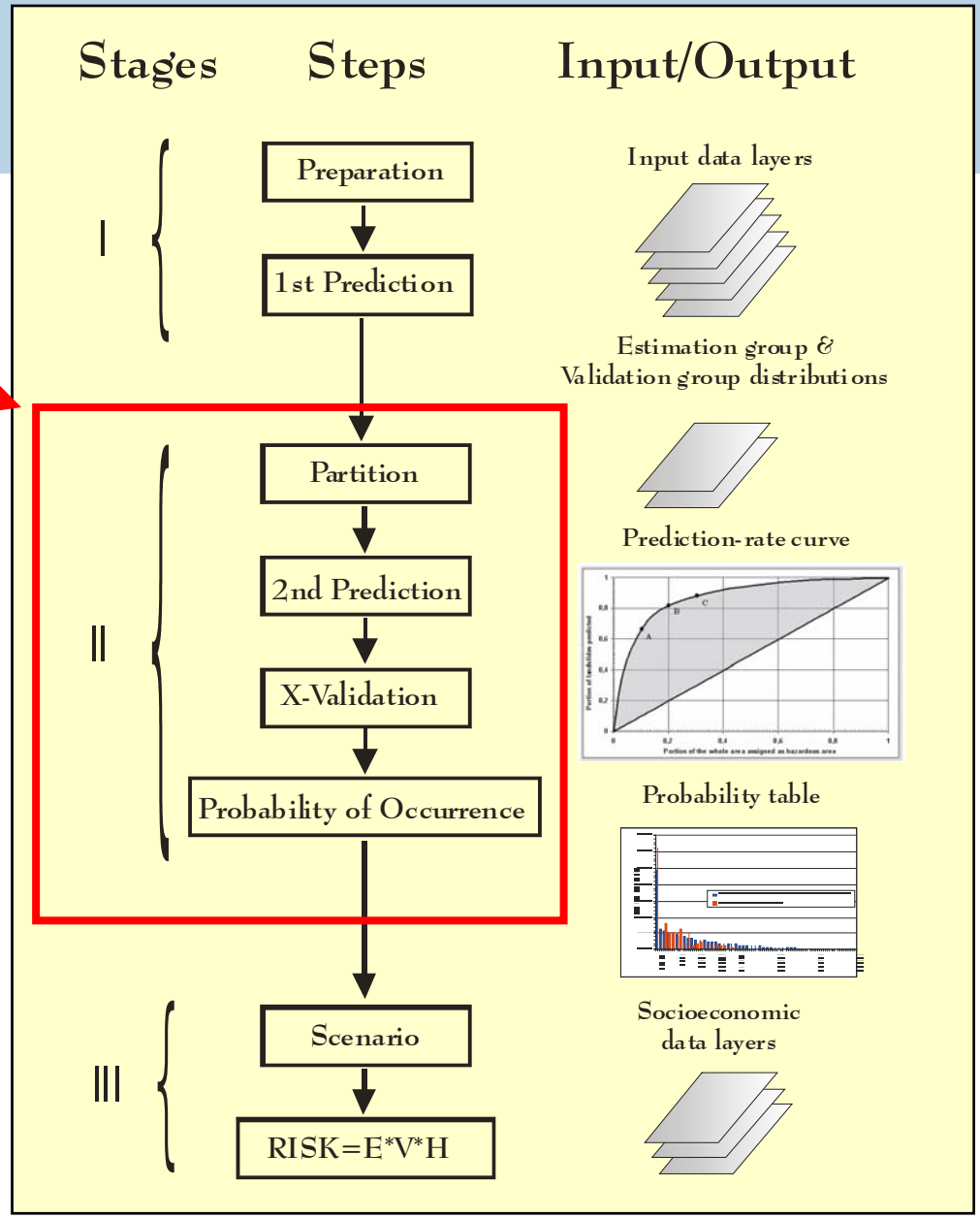
258,810.487 m E

266,930.487 m E

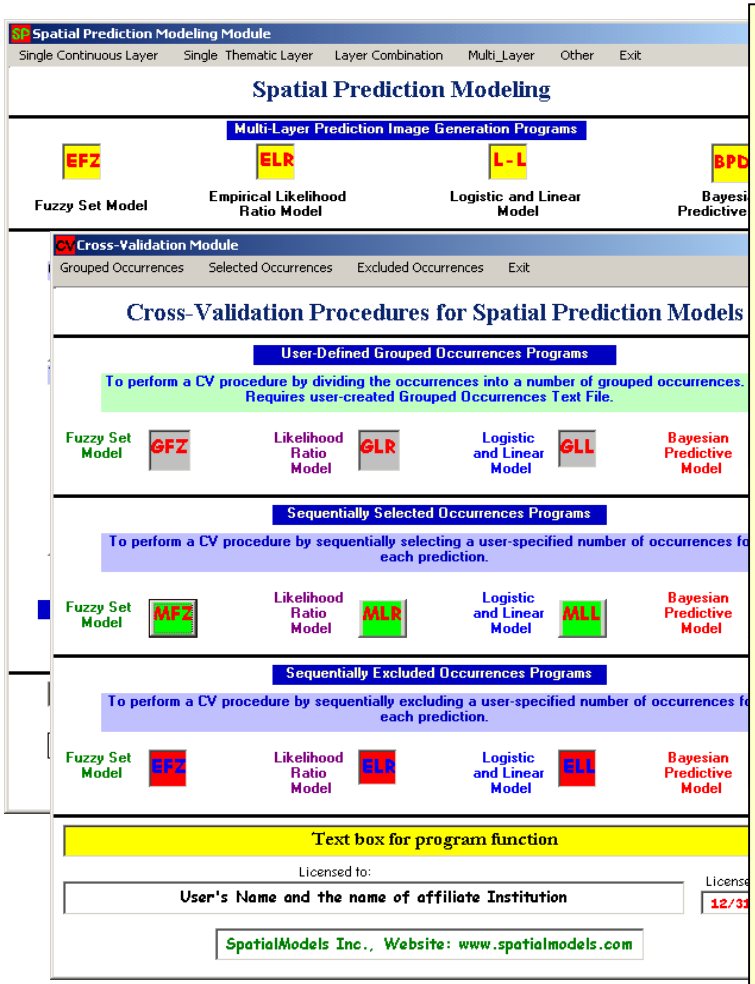


Most important part!

Spatial predictive modeling of hazard and risk



the Spatial Prediction Modeling system



SPM

Spatial Prediction Modeling System

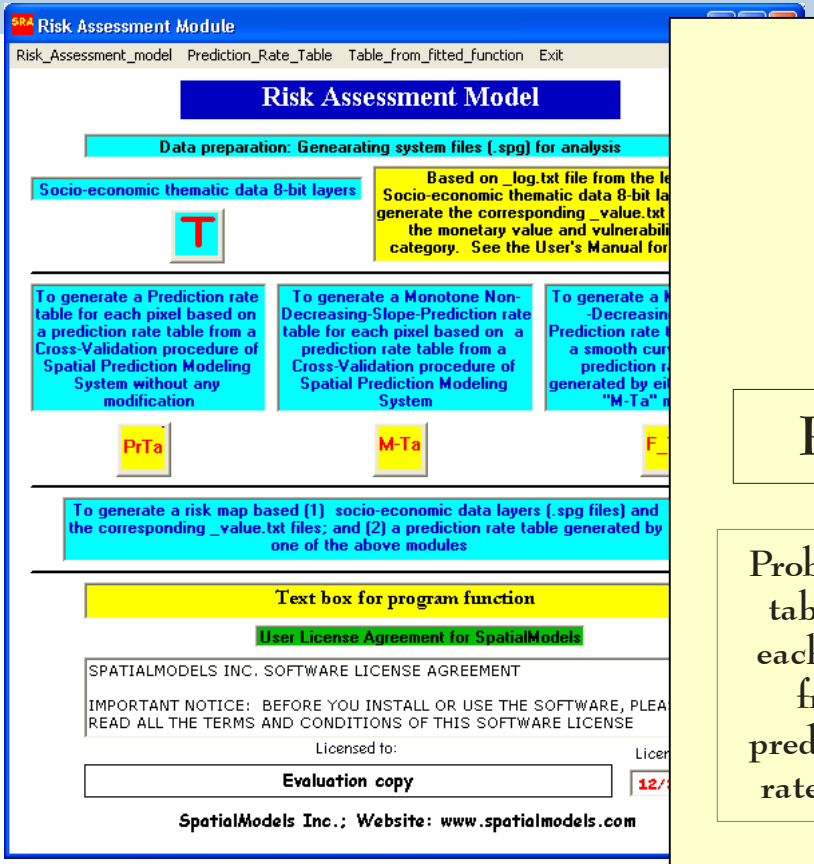
DP → SP → CV

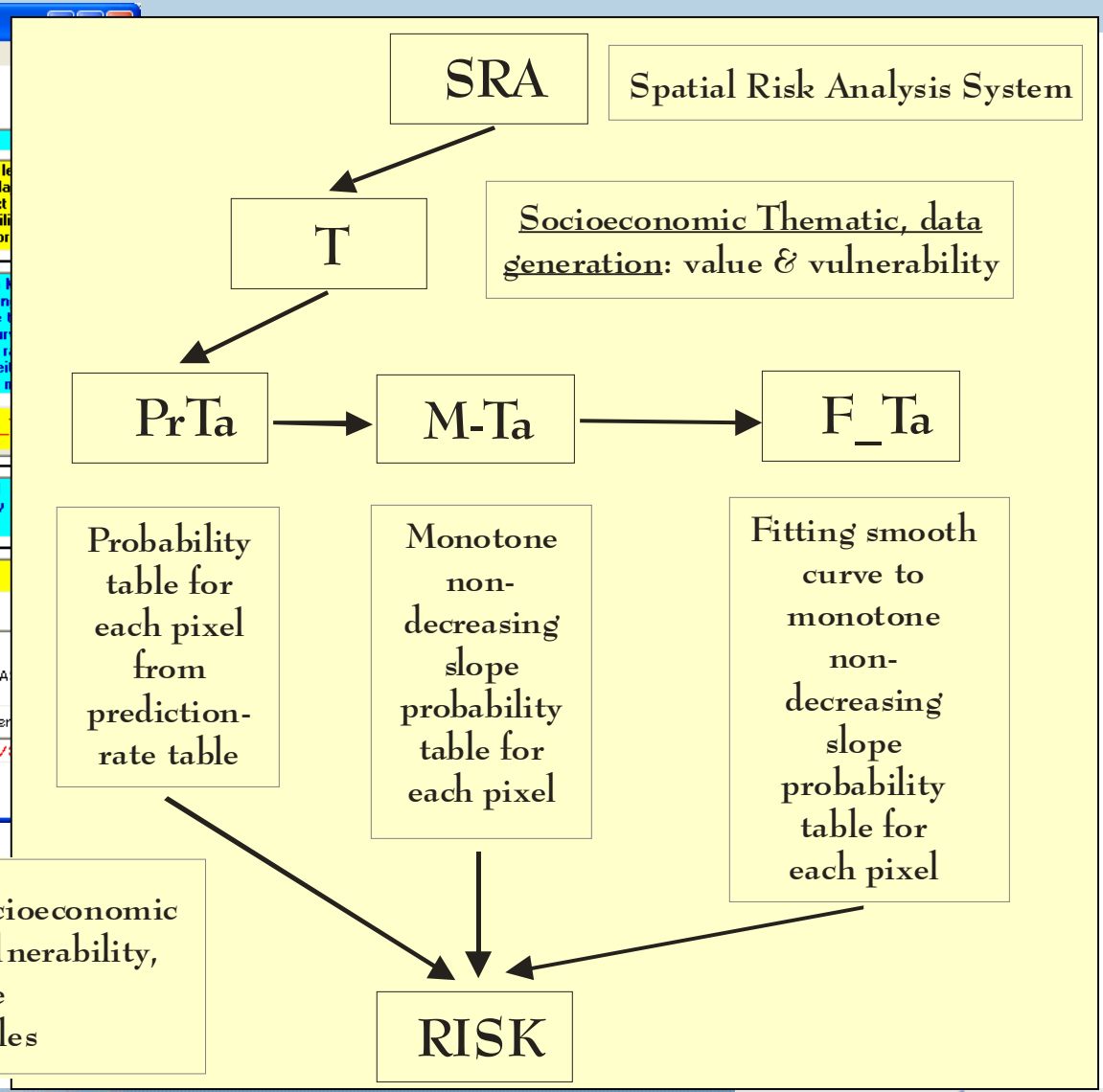
Data Preparation: Continuous, Thematic, and Occurrence data

Spatial Modeling: Multi-layer and layer-by-layer prediction image generation: Fuzzy sets, ELR, Logistic & Linear, and Bayesian model; Prediction-rate table generation

Cross-Validation: User defined grouped occurrences, Sequentially selected occurrences, and Sequentially excluded occurrences, for: Fuzzy set, ELR, Logistic & Linear, and Bayesian Predictive models

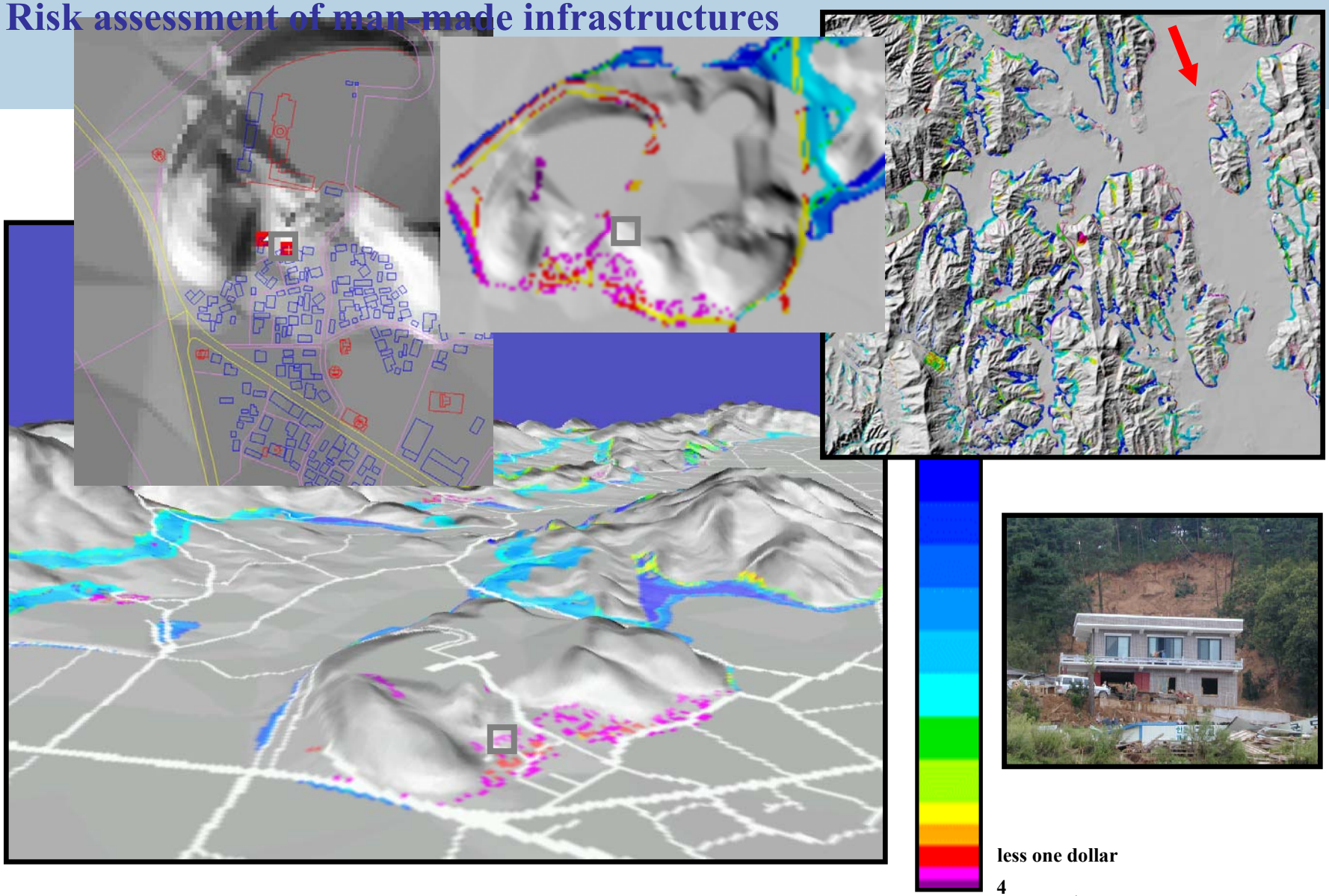
the Spatial Risk Analysis system





Generation of RISK map using the Socioeconomic Thematic data layers with value & vulnerability, the Hazard prediction image and one of the Probability tables

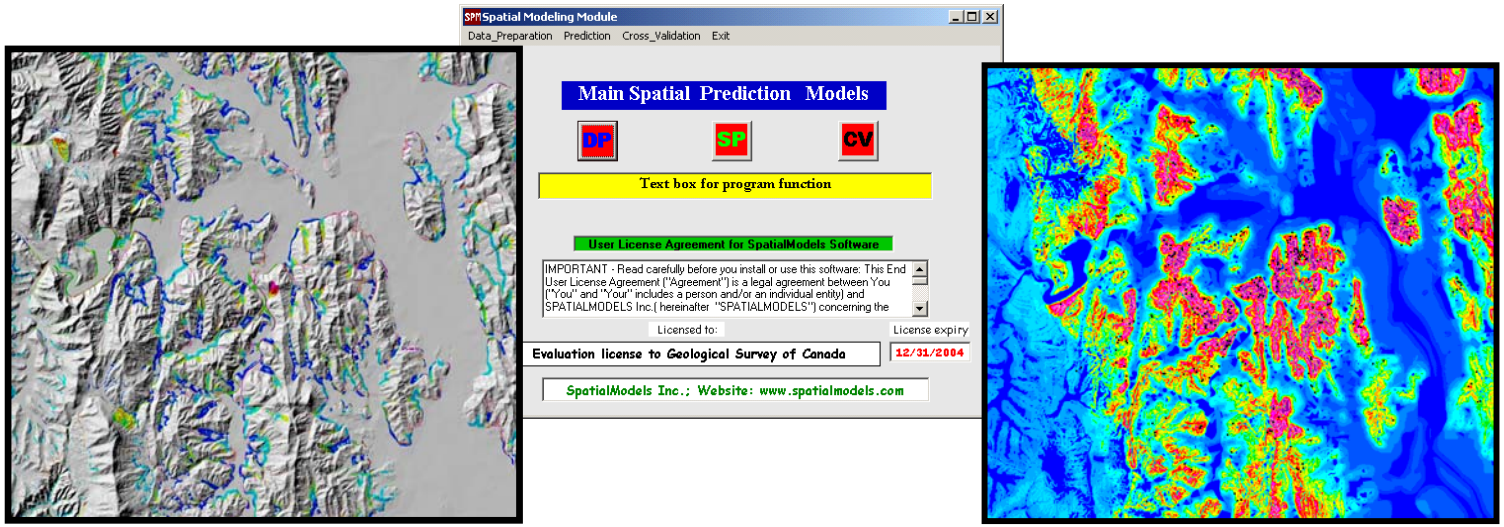
Risk assessment of man-made infrastructures



CONCLUSIONS

- Risk maps with **continuous risk levels** can be generated in many ways for many different **D-M**s
- They must deal with **future** hazards
- They must be based on **validation** of predicted hazard
- They must express the **certainty** levels of the risk levels
- Input **data certainty** defines *risk certainty*
- **Risk priority** should reflect *management priority*

risk spm hazard



Risk Assessment Using Spatial Prediction Models for Natural Disaster Preparedness

… what you would like to know about risk maps but do not dare asking …

Acknowledgement

This research was partly supported by the
Fifth Framework European Commission
Network Project
ALARM
Assessment of **LA**ndslide **R**isk and **M**itigation in Mountain Areas
Contract EVG1-CT-2001-00038

*http://www.*SPIN*lab.vu.nl/alarm*

*http://www.*SpatialModels.com