行政法人 國家災害防救科技中心
National Science and Technology Center for Disaster Reduction

The 10th JWWA/WRF/CTWWA
Water System Seismic Conference

Application of a Mesh-based Earthquake Impact Assessment Tool for water supply system on Policy Support

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2017/10/19

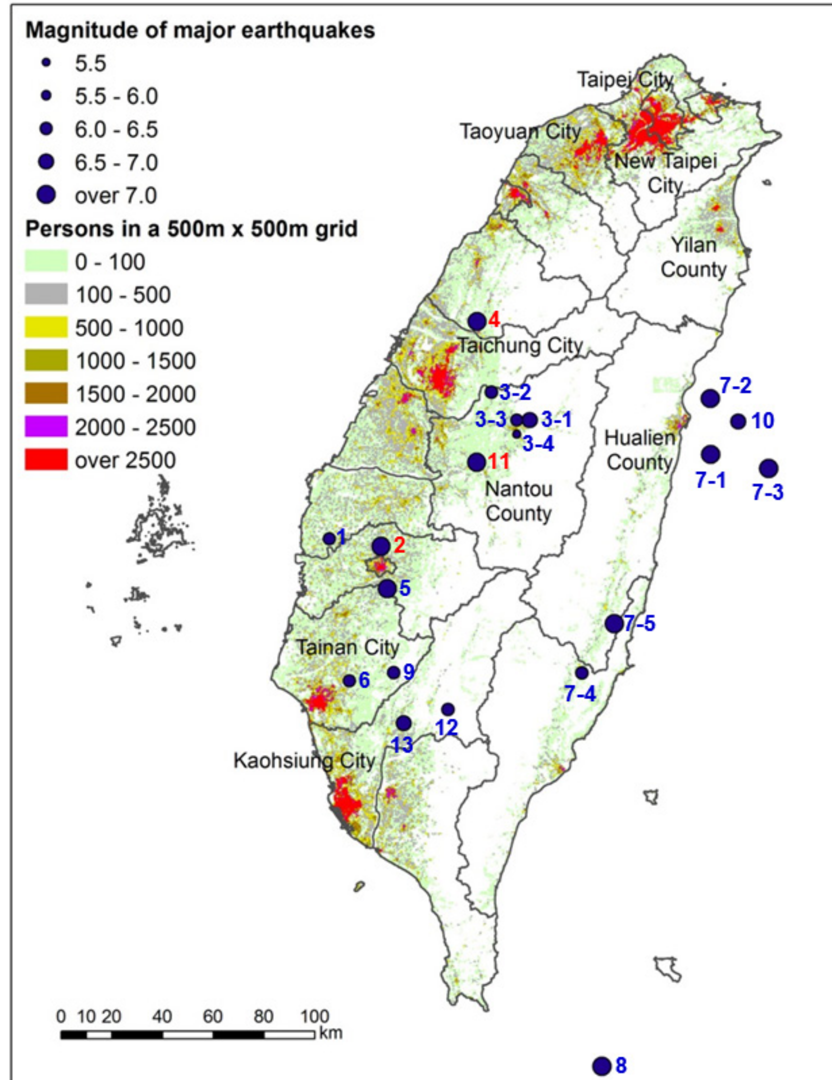
Outline

- Background
  - Major earthquake disasters in Taiwan
  - Requirements on disaster prevention
- Taiwan Earthquake Impact Information Platform, TERIA
- Application
  - Scenario simulation for the National Earthquake Drill
  - Impact analysis for policy suggestion on disaster management system

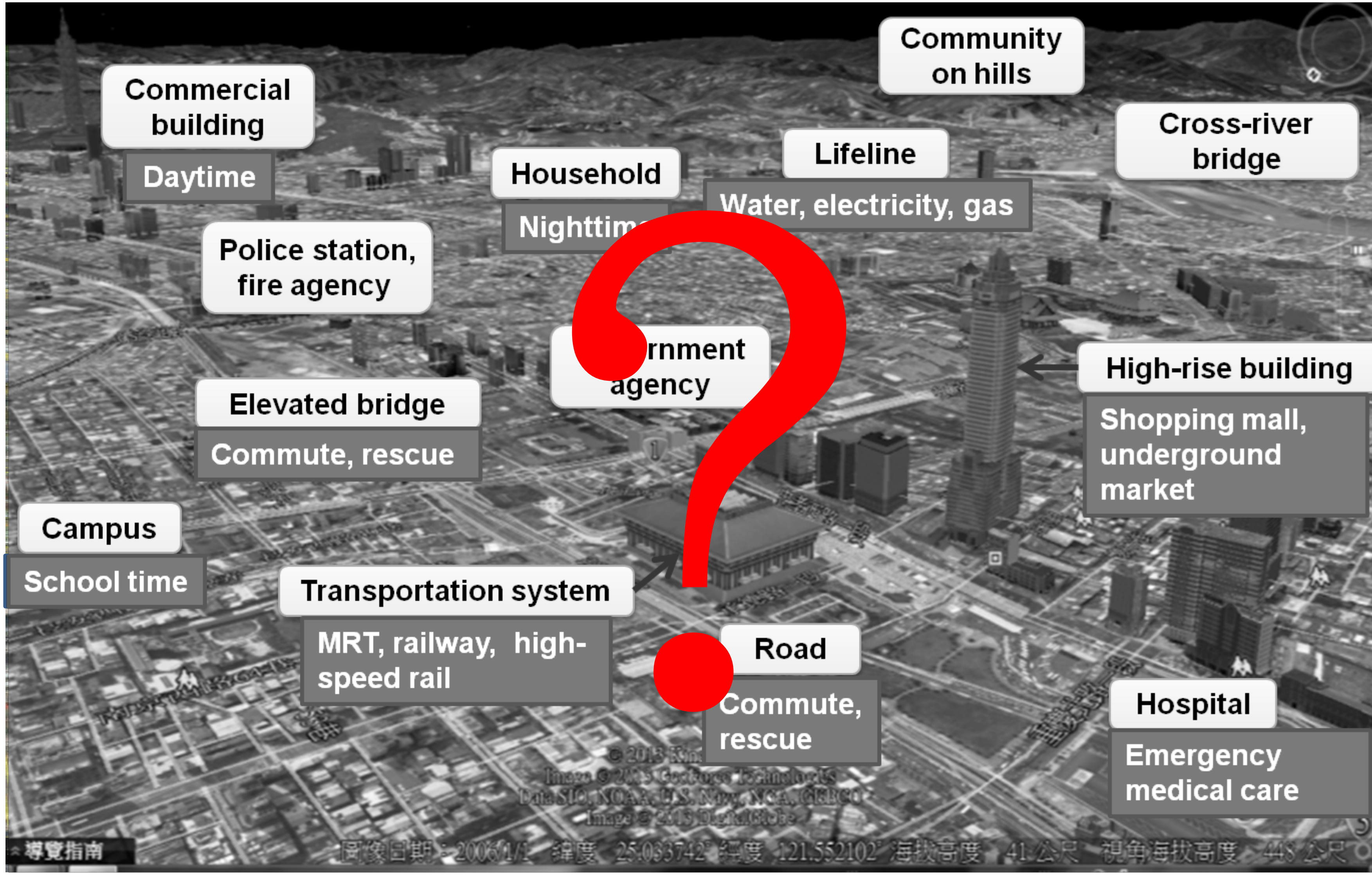
Major earthquake disasters in Taiwan

- Meishan earthquake(1906): M_L=7.1, 1,258 death
- Hsinchu-Taichung(1935): M_L=7.1, 3,276 death
- Ch-Chi earthquake(1999): M_L=7.3, 2,405 death

No.	Earthquake	Date	Magnitude (M_L)	Depth (km)	Casulties	
					Ceased	Injured
1	Douliou	1904/11/06	6.1	7.0	145	158
2	Meishan	1906/03/17	7.1	6.0	1,258	2,385
3	Nantou Series	1916/08/28	6.8	45.0	71	285
		1916/11/15	6.2	3.0		
		1917/01/05	6.2	0.0		
		1917/01/07	5.5	0.0		
4	Hsinchu-TaiChung	1935/04/21	7.1	5.0	3,276	12,053
5	Chungpu	1941/12/17	7.1	12.0	358	766
6	Hsinhua	1946/12/05	6.1	5.0	74	182
7	Longitudinal Valley Series	1951/10/22	7.3	4.0	>85	>1,000
		1951/10/22	7.1	1.0		
		1951/10/22	7.1	18.0		
		1951/11/25	6.1	16.0		
		1951/11/25	7.3	36.0		
8	Hengchun	1959/08/15	7.1	20.0	17	85
9	Paiho	1964/01/18	6.3	18.0	106	653
10	Hualien	1986/11/15	6.5	15.0	13	45
11	Chi-Chi	1999/09/21	7.3	8.0	2,405	11,305
12	Tauyuan	2010/03/04	6.4	5.0	0	96
13	Meinong	2016/02/06	6.6	14.6	117	551



Are we ready for the next major earthquake?



Requirement on preparedness and management

Emergency preparedness

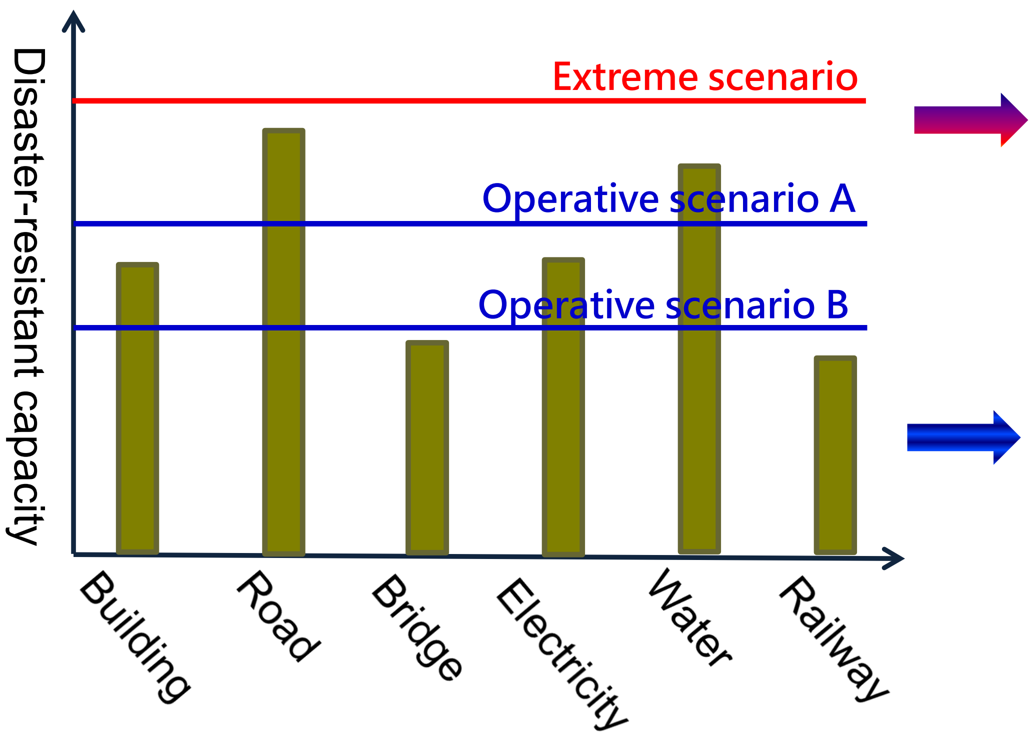
- The results of scenario simulation have not been properly applied on the Emergency preparedness in the Local Disaster Prevention and Response Plan
- The practical disaster scenario of large-scale earthquakes has not been fully considered in the planning of earthquake drills

Disaster management

- Subjected to an large-scale earthquake, the disaster resilience of organizations should be examined

Concept of this study

- Impact analysis in various levels of excitations
  - Mesh-based scenario simulation
  - Check the weak point and its spacial distribution
  - Examine the disaster-resistant capacity of each item



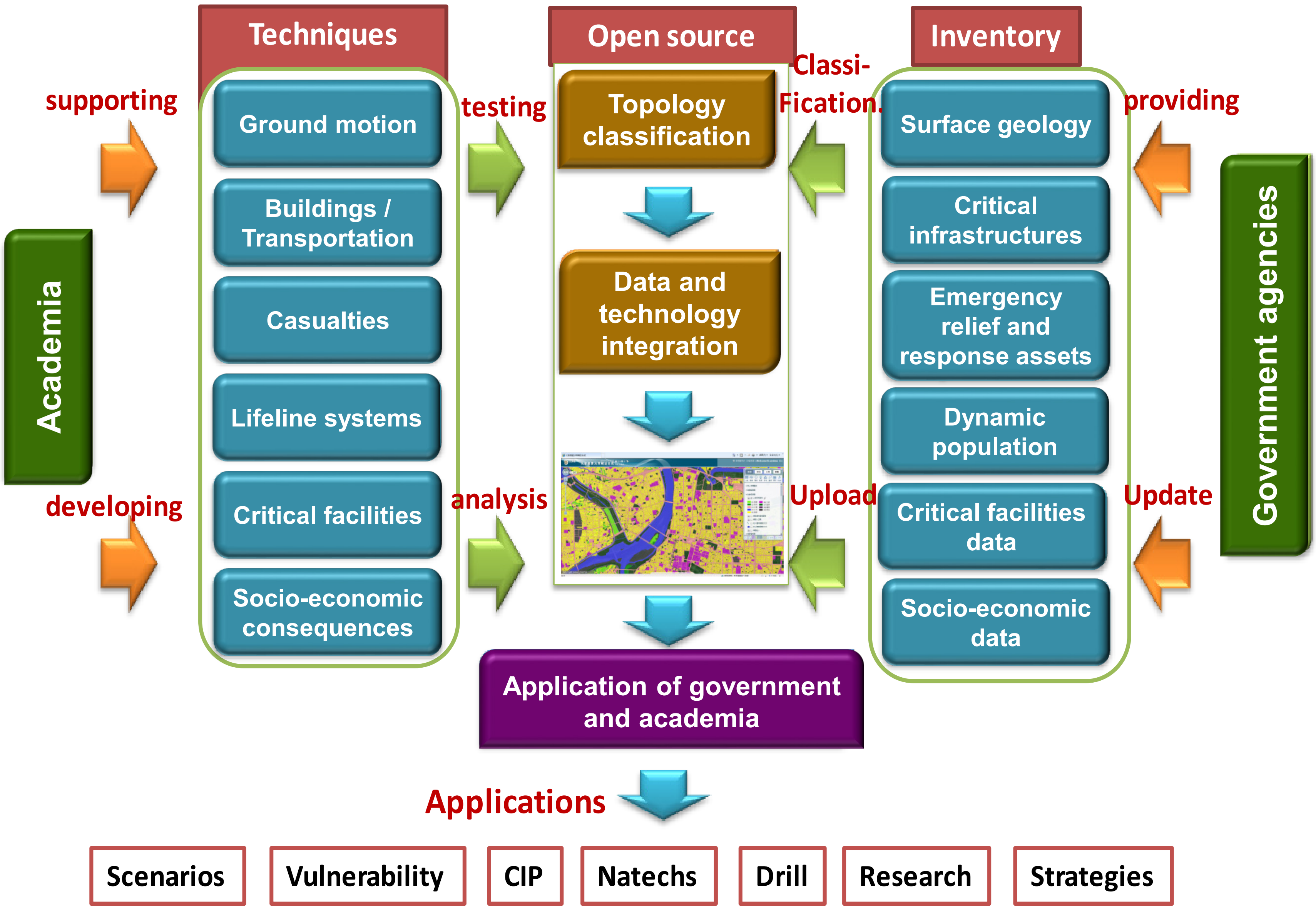
1. Extreme scenario

Quantitative analysis in an extreme scenario allows the disaster resilience of organizations to be examined

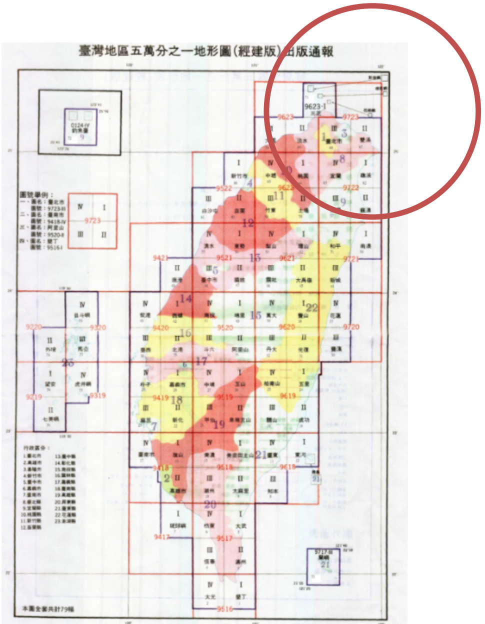
2. Operative scenario

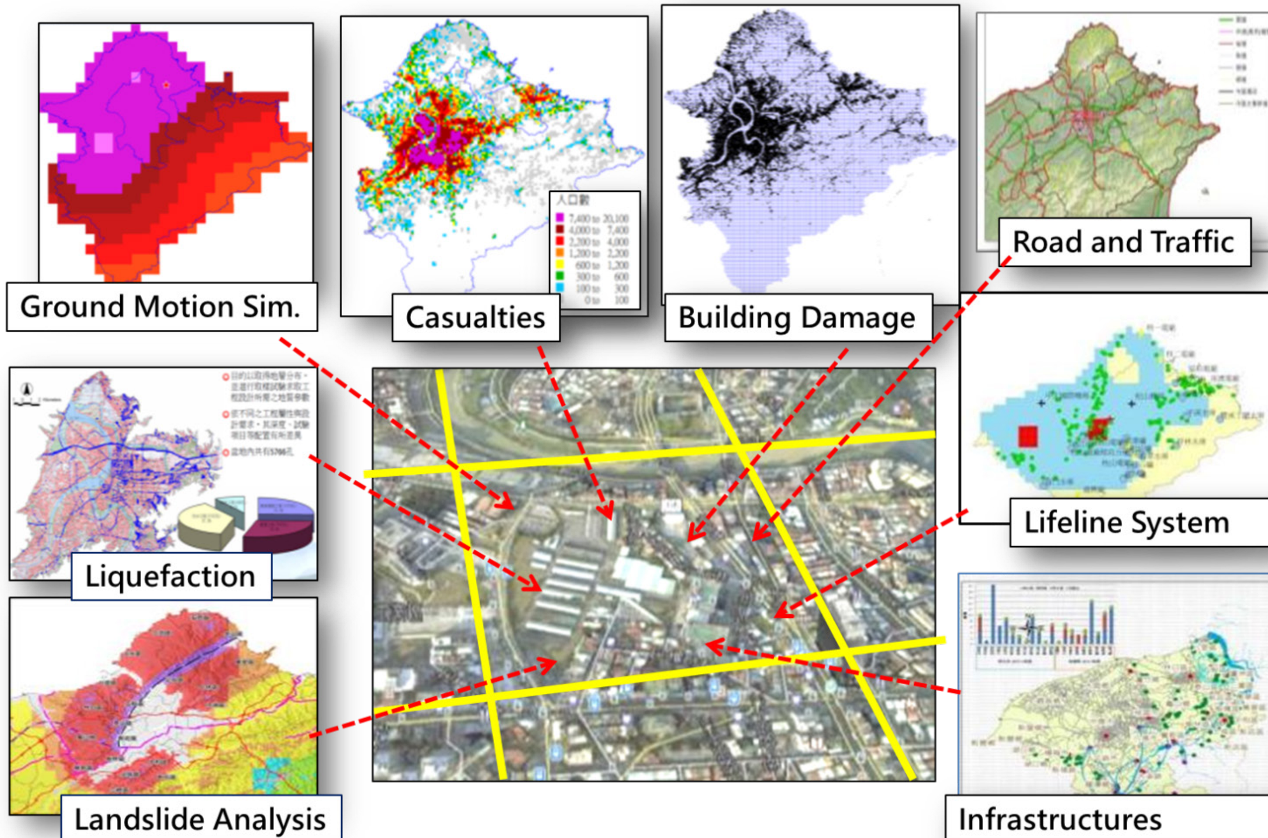
Scenario simulation in various levels of excitations can be applied on the local plan to enhance the capacity

TERIA Platform Framework



Geospatial Meshed Data





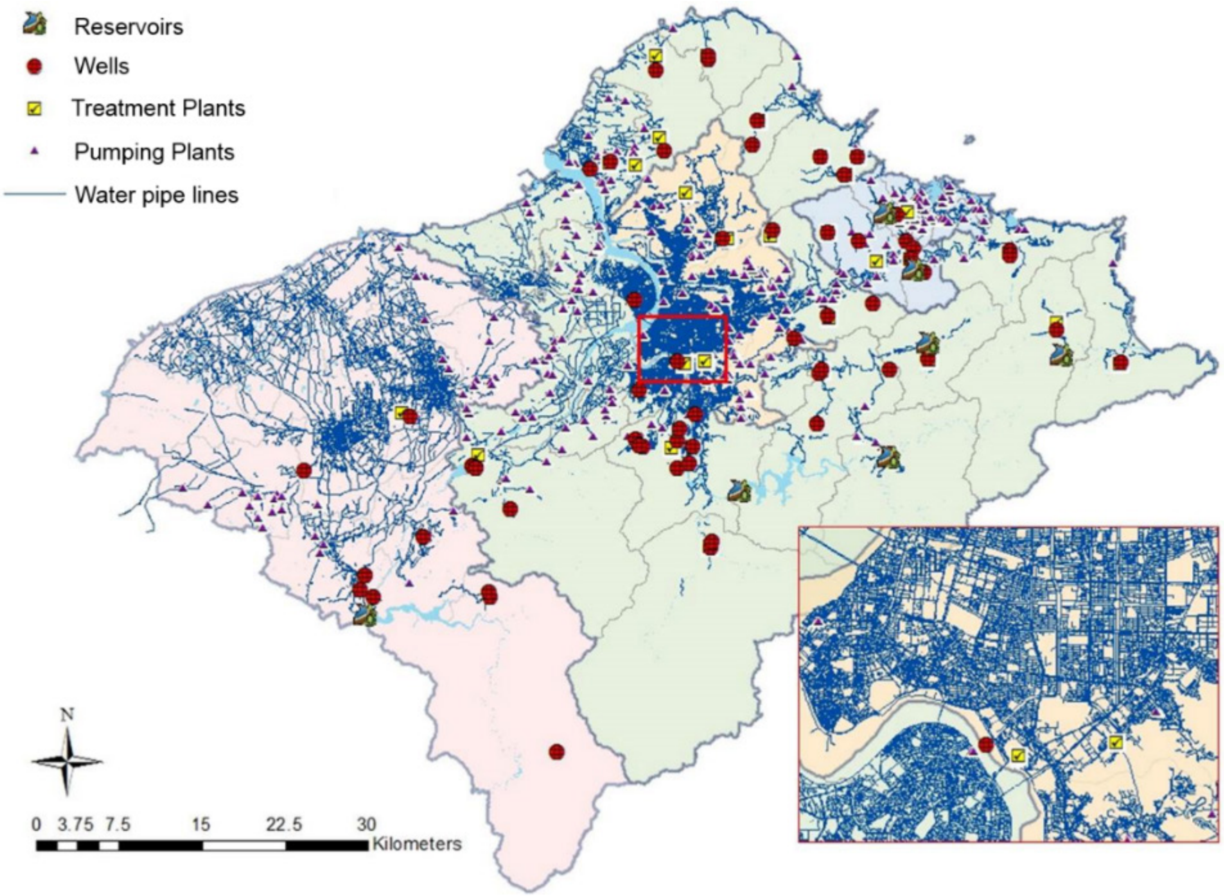
500m x 500m Meshed Map Sheet

Number of Grids :132,712

Database of portable water system

Classification of pipe material

Type	Material
Brittle pipeline	ACP, CIP, PCCP, PCV, PCVP, PCV/PE, PCVP+DIP, PCVPE. RCP
Ductile pipeline	Others



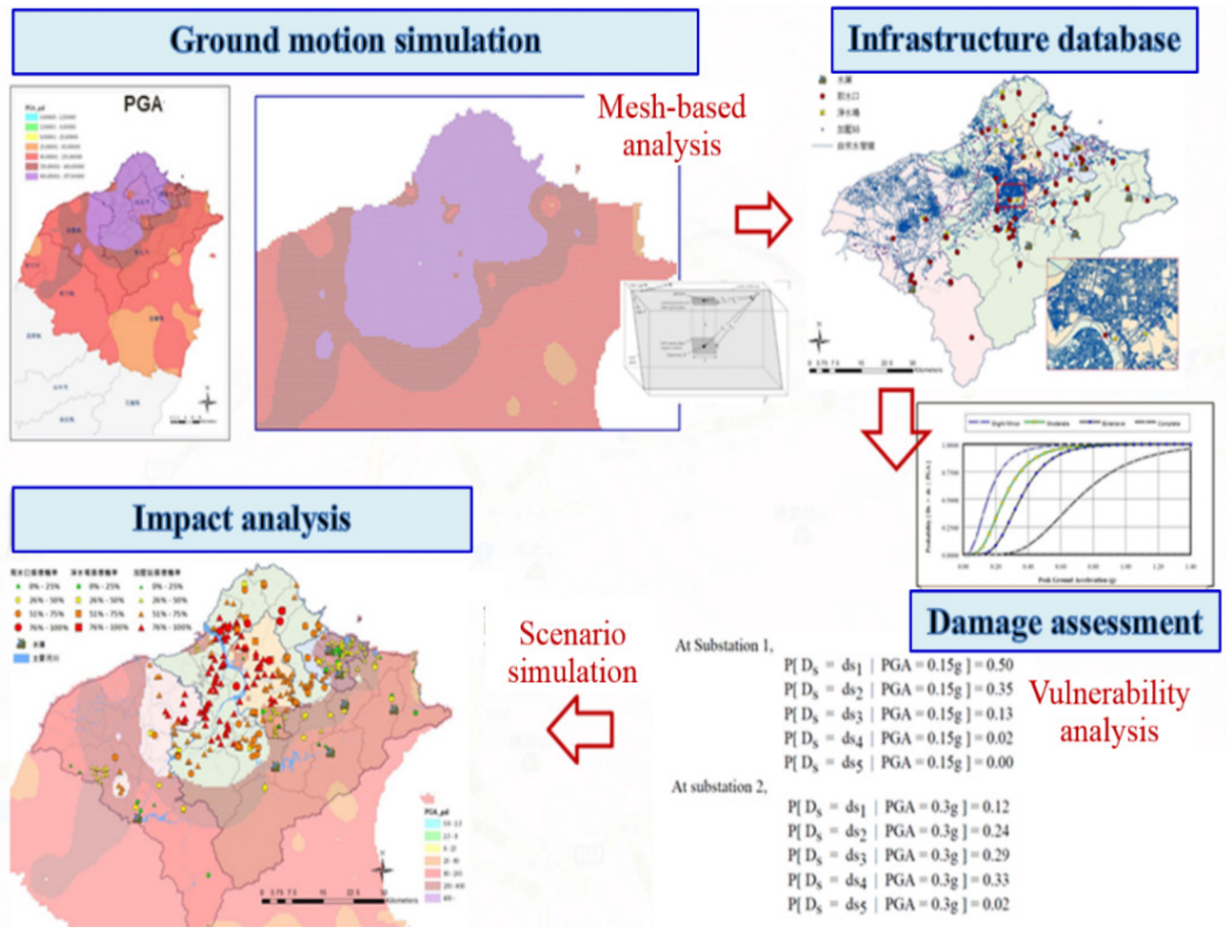
*Acknowledgment to the Taiwan Water Corporation and Taipei Water Department

Analysis methodology

Damage Function for Portable Water Facility

- Water Treatment Plant
- Pumping Plant
- Well
- Anchored Storage Tank

$$p = \frac{1}{2} + \frac{1}{2} erf\left(\frac{\ln PGA - m}{\sqrt{2}\beta}\right)$$



Damage Functions for Buried Pipelines

$$RR_{PGV}[\text{Repair s/km}] = 0.0001 \times (PGV)^{2.25}$$

$$RR_{PGD}[\text{Repair s/km}] = Prob[liq] \times (PGD)^{0.56}$$

$$p = \frac{1}{2} + \frac{1}{2} erf\left(\frac{\ln \alpha - m}{\sqrt{2}\beta}\right)$$

$$R_{brittle} = (RR_{PGV} \times 20\% + RR_{PGD} \times 80\%) \times L$$

$$R_{ductile} = 30\% \times (RR_{PGV} \times 20\% + RR_{PGD} \times 80\%) \times L$$

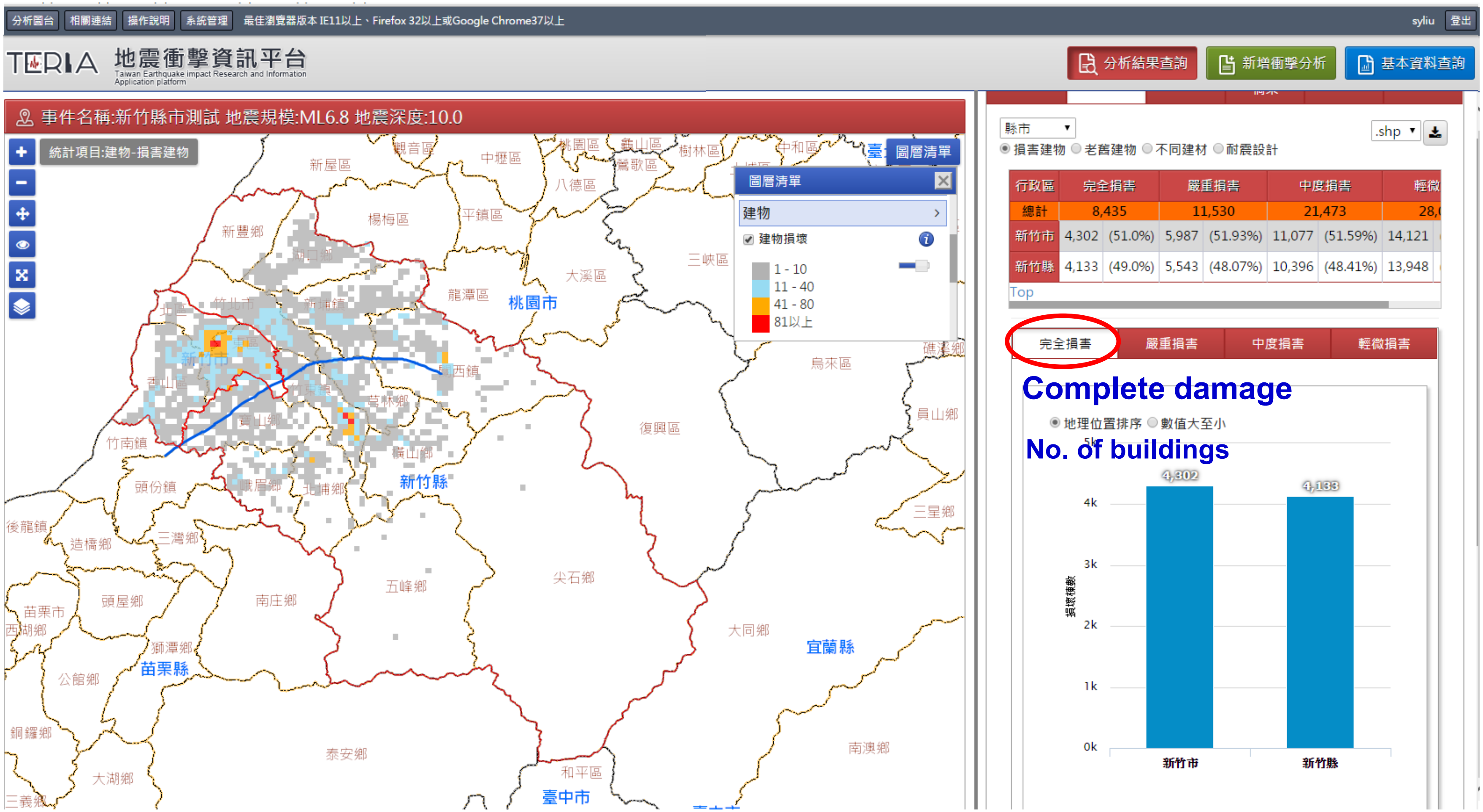
$$\alpha = (R_{brittle} + R_{ductile})/L$$

Create an event for simulation

- Line source: Fault name, magnitude, depth
- Point source: Longitude and latitude of epicenter
- User-defined distribution of ground motion

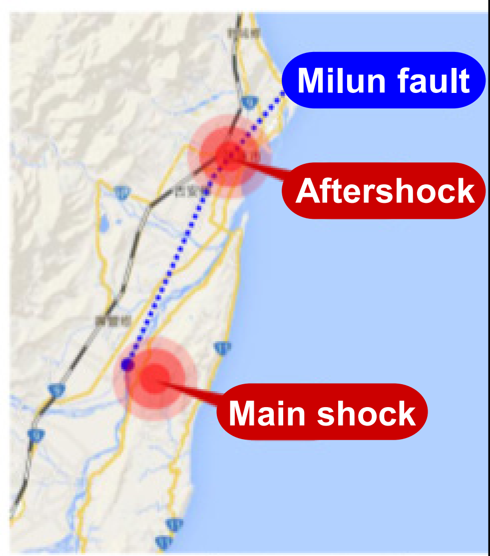
Interpret the analytical results

Display detailed results



Scenario simulation for the National Earthquake Drill

Line source: Milun Fault

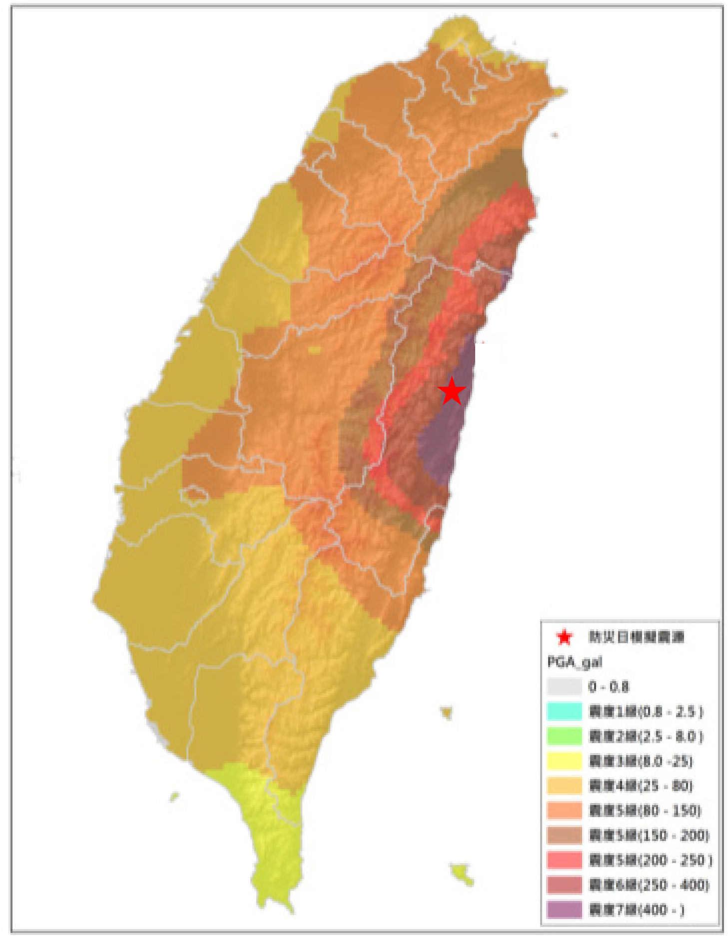


Location of main shock and aftershock

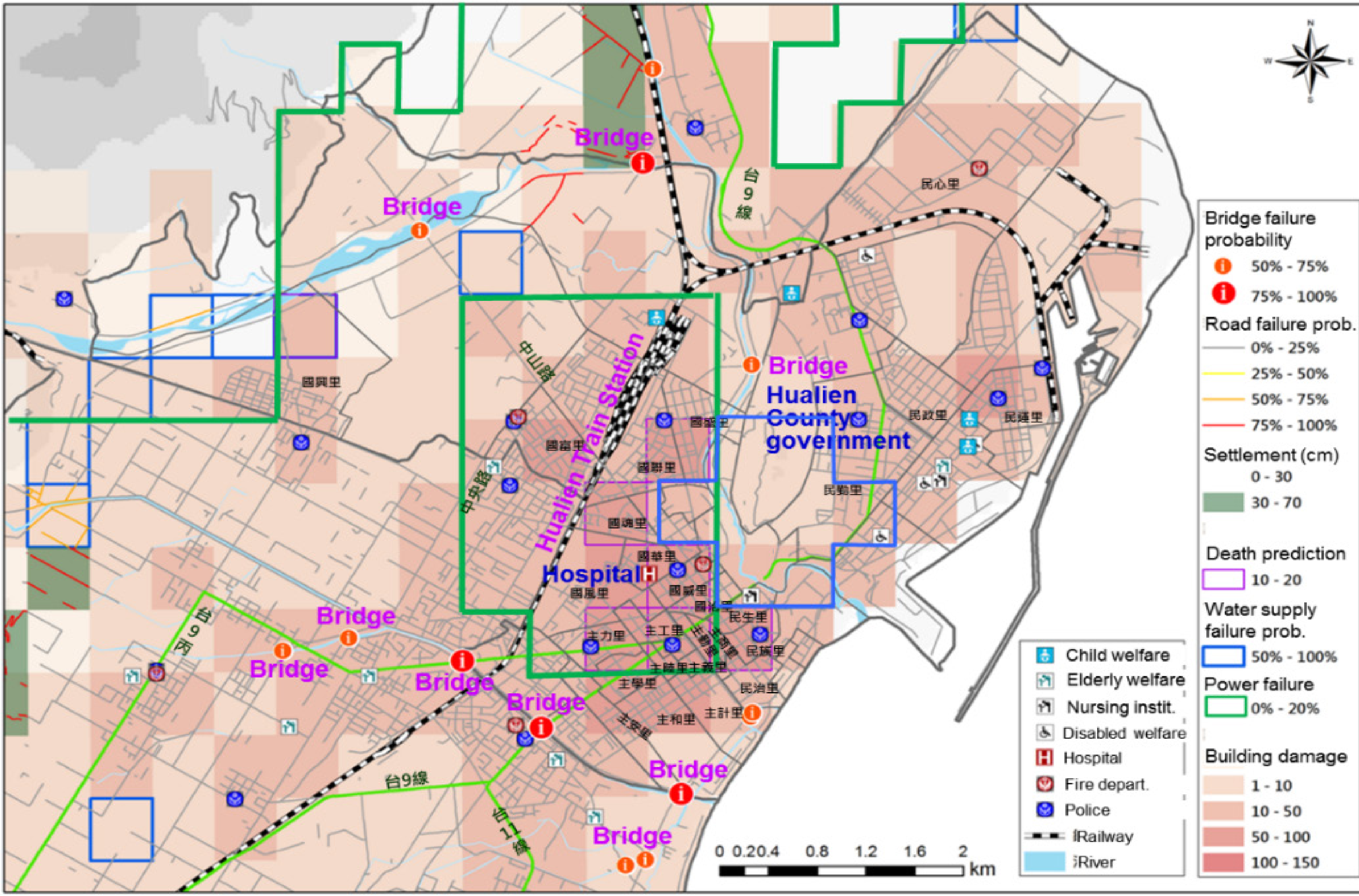
Scenario

Time: am9:21 Sep. 21, 2014
Weather: sunny, 31℃
Epicenter: Shoufeng township, Hualien county
Event: M_L=7.0, depth=10km, intensity exceeds Level 7 in some areas

Ground motion distribution

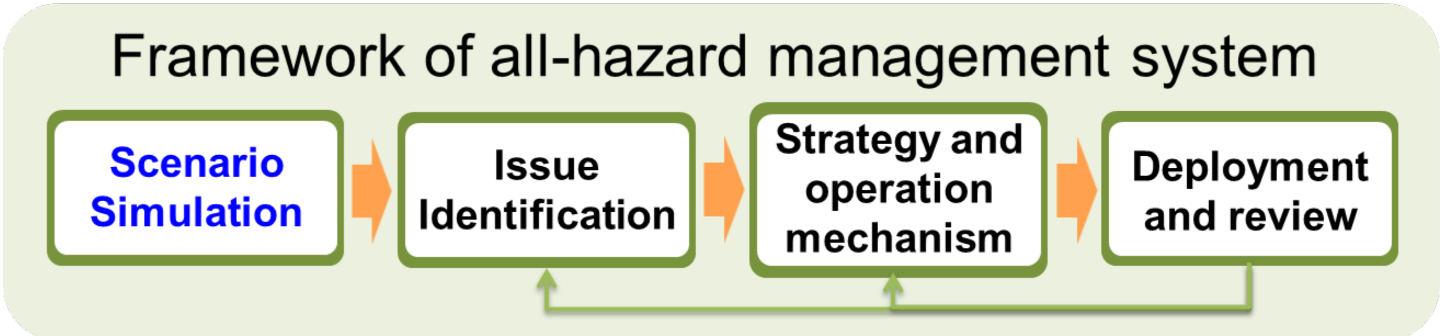


Integration of analysis results in Hualien



Impact analysis for disaster management

- The expert consultation committee* requested a scenario, an urban city subjected to large-scale earthquakes, to disclose the challenges in the disaster management system



Simulation items

- Soil liquefaction
- Building
- Casualty
- Sheltering
- Transportation
- Mass medical care
- Lifeline system

*Disaster Prevention and Protection Expert Consultation Committee, the Executive Yuan

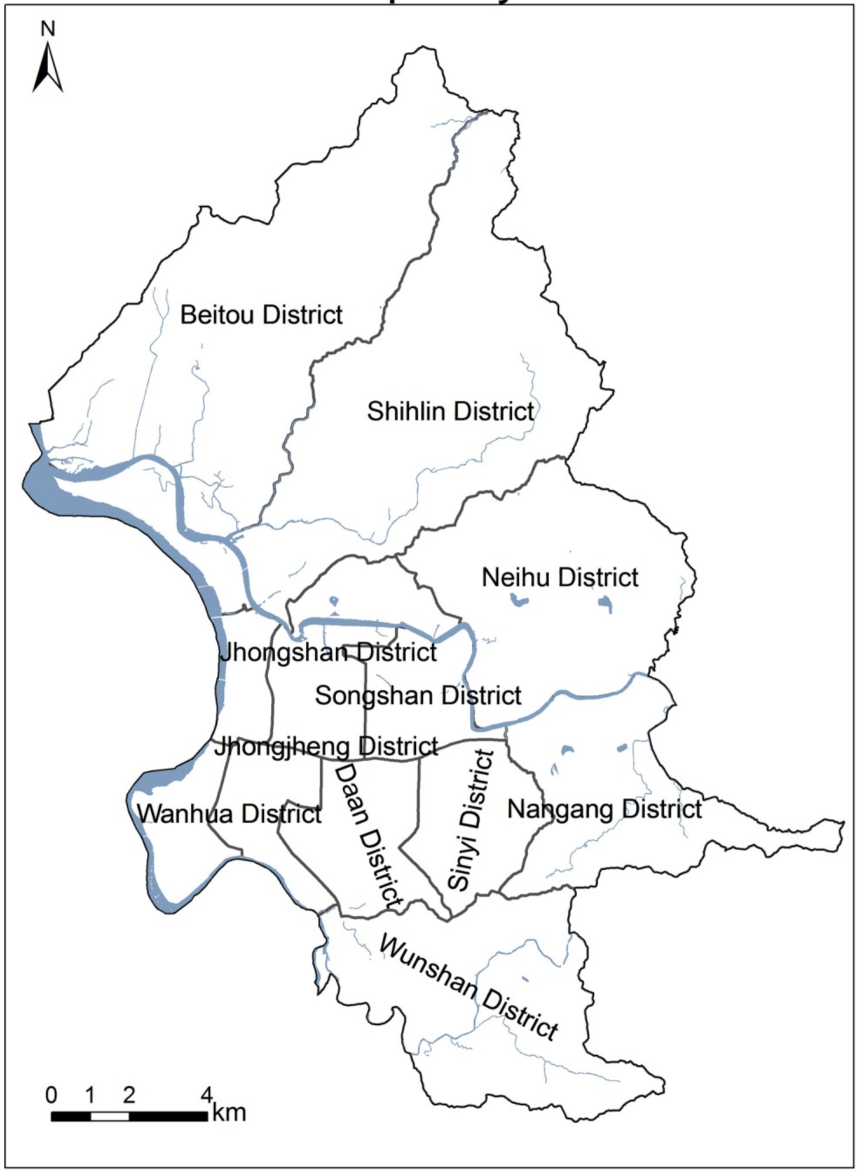
Simulation in various shaking intensities

Intensity level	Acceleration range	Scenario setting
V	80~250gal	240gal*
VI	250~400gal	320gal*
VII	>400gal	450gal**

* Based on the building code in return periods of 475 and 2500 years

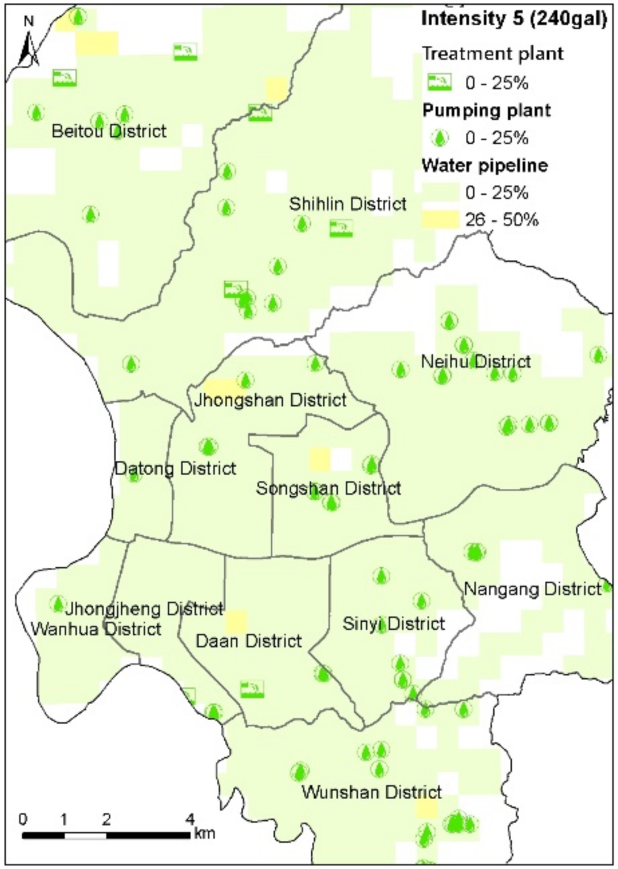
**According to the average PGA measured in the central Taiwan for the Chi-Chi earthquake

Taipei city

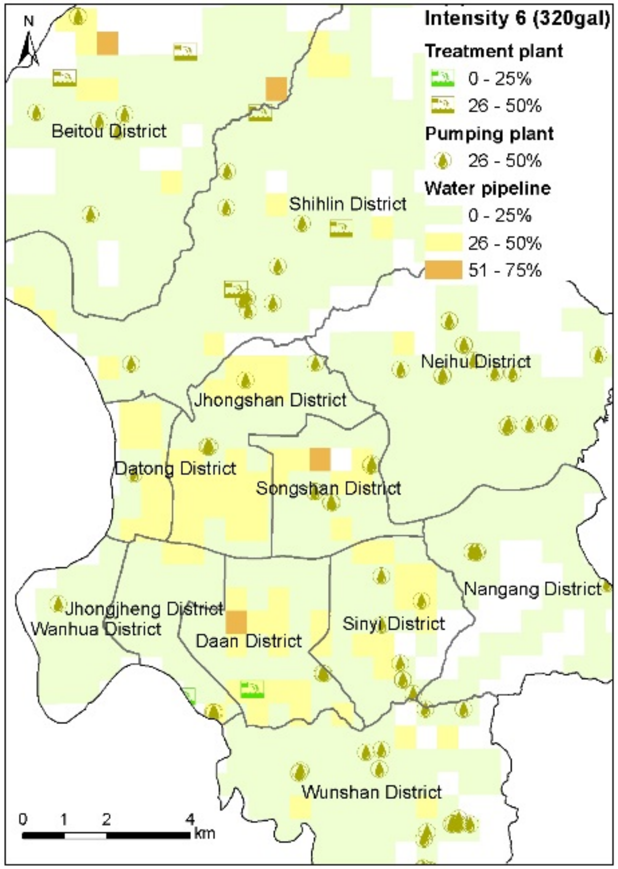


Damage assessment for water supply system

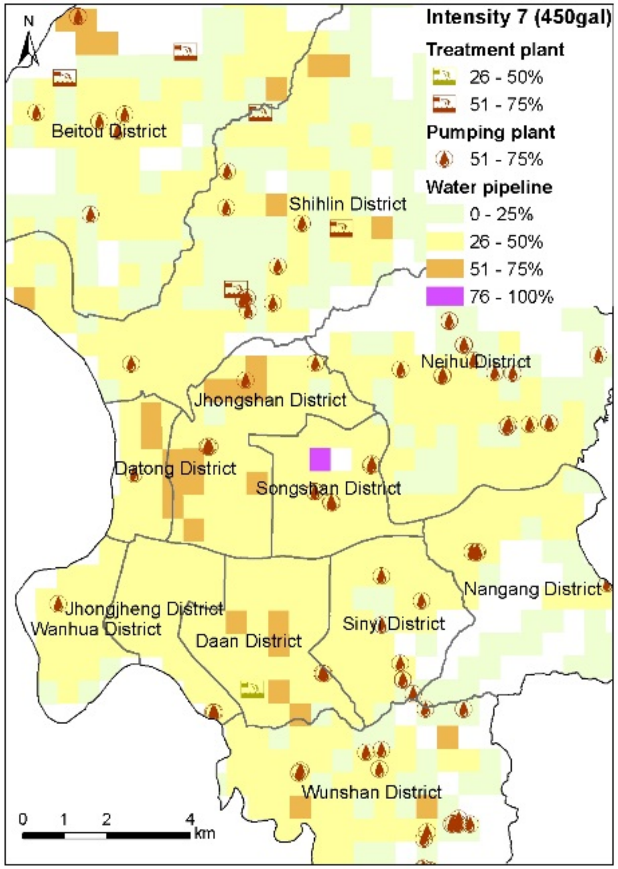
Intensity 5
(PGA=240 gal)



Intensity 6
(PGA=320 gal)



Intensity 7
(PGA=450 gal)



Application on policy suggestion

Simulation time: daytime

❶ **Serious building damage and casualty**

- Building damage > 5,000
- Serious injure and death ~ 6,000

❷ **Heavy medical care demand**

- Hospitalization demand > 4,000 (need 2,000 to balance)

❸ **Shelter overloading**

- Shelter demand > 190,000 (need 30,000 to balance)

❹ **Roads and bridges severely disconnected**

★ Power failure in the whole city

➡ **Rescue, medical care, transportation, sheltering, communication will be interrupted**

Suggestions on disaster management system

- **Launch a task force for configuration and promotion**
- **Inter-ministry coordination and administrative mechanism**
- **Enhance the resilience and continuity operation of infrastructure**
- **Promote the application of scenario simulation on disaster management**

Conclusion

- The TERIA platform is capable of analyzing the response of ground motion, potential of liquefaction and landslide, casualty, damages of building, road, bridge, electricity, and portable water system.
- The scenario simulations for various levels of excitations interpreted in a mesh of 500 m × 500 m are helpful to disclose the possible disaster scenarios in details.
- Those accomplishments have been applied to the operation of the National Earthquake Drill and the policy suggestions for disaster management.
- Wu would like to cooperate with CTWWA, TWC, and TWP to develop the domestic parameters of fragility curves for water supply facilities and pipelines using historic disaster data.

Thank you

for your attention