The quick response for earthquake disaster: assessment module and implements

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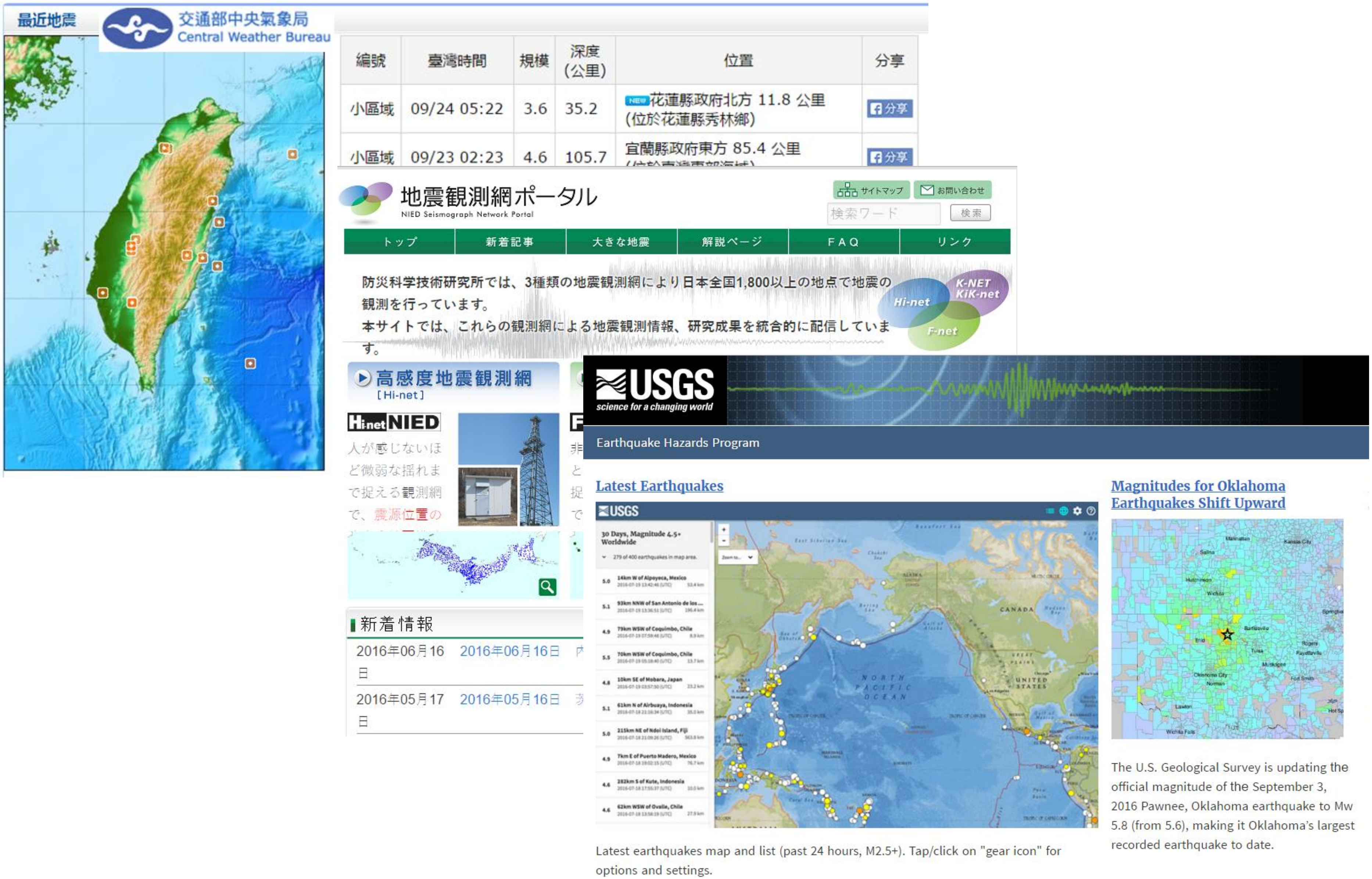
Earthquake Information



Quick response to the public

Reduce the chance of injury

HOW TO PROTECT YOURSELF DURING AN EARTHQUAKE...

OFFICIAL RESCUE TEAMS from the U.S. and other countries who have searched for trapped people in collapsed structures around the world, as well as emergency managers, researchers, and school safety advocates, all agree that "Drop, Cover, and Hold On" is the appropriate action to reduce injury and death during earthquakes. *Methods like standing in a doorway, running outside, and "triangle of life" method are considered dangerous and are not recommended (see below).*

Topics addressed below include:

- What to do wherever you are when shaking begins
- Why experts recommend Drop, Cover, and Hold On
- What experts do not recommend you do during an earthquake

WHAT TO DO IMMEDIATELY WHEN SHAKING BEGINS

Your past experience in earthquakes may give you a false sense of safety; you didn't do anything, or you ran outside, yet you survived with no injuries. Or perhaps you got under your desk and others thought you overreacted. However, you likely have never experienced the kind of strong earthquake shaking that is possible in much larger earthquakes: sudden and intense back and forth motions of several feet per second will cause the floor or the ground to jerk sideways out from under you, and every unsecured object around you could topple, fall, or become airborne, potentially causing serious injury. This is why you must learn to immediately protect yourself after the first jolt... don't wait to see if the earthquake shaking will be strong!

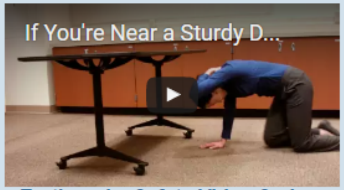
In MOST situations, you will reduce your chance of injury if you:

DROP where you are, onto your hands and knees. This position protects you from being knocked down and also allows you to stay low and crawl to shelter if nearby.

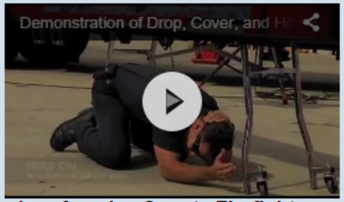
COVER your head and neck with one arm and hand
- If a sturdy table or desk is nearby, crawl underneath it for shelter
- If no shelter is nearby, crawl next to an interior wall (away from windows)
- Stay on your knees; bend over to protect vital organs

HOLD ON until shaking stops
- Under shelter: hold on to it with one hand; be ready to move with your shelter if it shifts
- No shelter: hold on to your head and neck with both arms and hands.

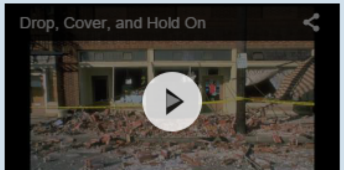
Wherever you are, protect yourself! It is important to think about what you will do to protect yourself wherever you are. What if you are driving, in a theater, in bed, at the beach, etc.? **Step 5** of the *Seven Steps to Earthquake Safety* describes what to



Earthquake Safety Video Series: Simple videos demonstrating what to do to protect yourself in various situations (near a table, no table nearby, in a theater/auditorium, at the shore, while driving, and more to come).



Los Angeles County Firefighters demonstrate Drop, Cover, and Hold On



http://www.earthquakecountry.org/dropcoverholdon/

Quick response to the official government

Seismic Risks

- High intensity areas
- Population in risk
- Infrastructure
- Traffic system
- Damaged-prone buildings and casualties
- Others.

Outlines

- **Introduction**
- **Seismic Risk Identification**
- **Assessment module**
  - Earthquake-induced landslide
  - Soil liquefaction
  - Building collapse and Casualties
- **Implements (Tools) and Application**

Introduction

Disaster Management Cycle

Minimizing the effects of disaster.
Examples: building codes and zoning; vulnerability analyses; public education.

Planning how to respond.
Examples: preparedness plans; emergency exercises/training; warning systems.

Returning the community to normal.
Examples: temporary housing; grants; medical care

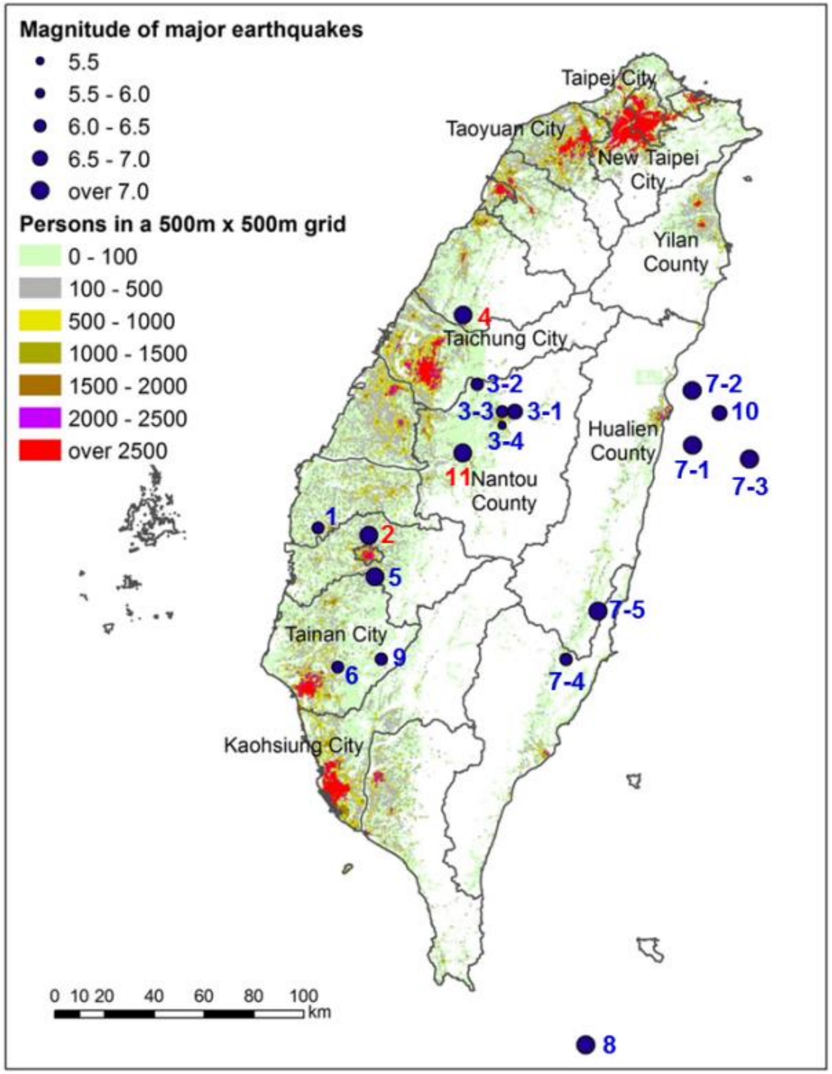
Efforts to minimize the hazards created by a disaster.
Examples: search and rescue; emergency relief

http://www.gdrc.org/uem/disasters/1-dm_cycle.html

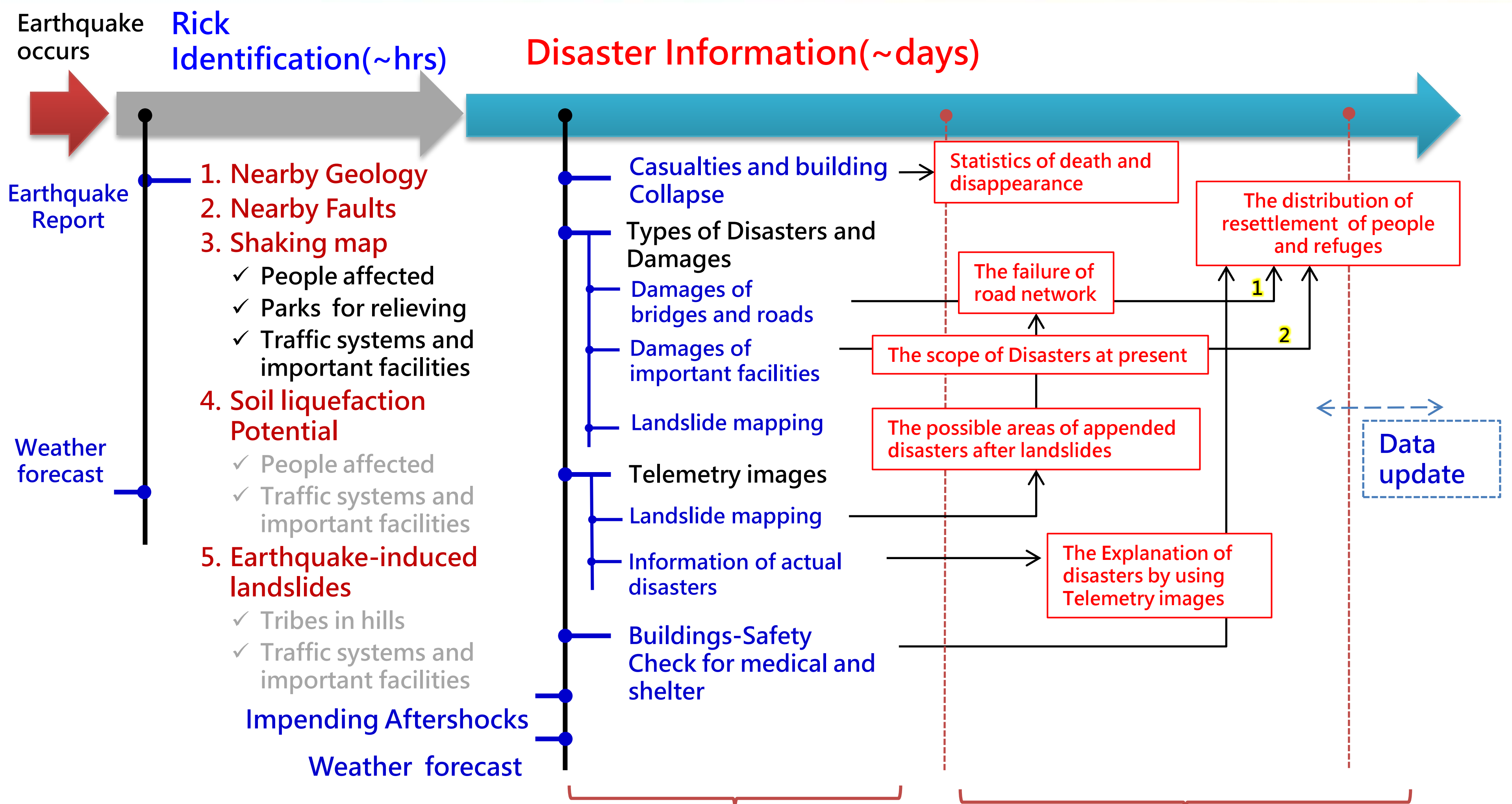
Earthquake disasters in Taiwan

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

No.	Earthquake	Date	Magnitude (M_L)	Depth (km)	Casulties	
					Decease	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



NCDR Supports CEOC



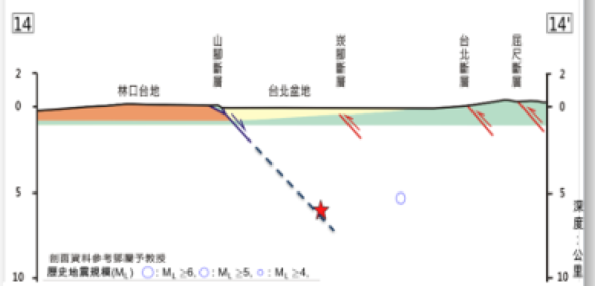
Type1 : Disaster Maps with Statistical tables
Type2 : GIS-based information. (e.g., Integrated Platform on Information and Intelligence of Disasters, NCDR)

Type1 : Disaster Maps with Statistical tables and trends
Type2 : GIS-based information. (e.g., Integrated Platform on Information and Intelligence of Disasters, NCDR)

Scenario-based Maps

震源鄰近區域地質剖面圖

Geology and Fault



地表加速度(PGA)分布圖

Peak Ground Acceleration

各地震度分布

縣市	震度	PGA (gal)
新北市	7	451.0
台北市	7	445.4
桃園市	6	300.9

震度分級
- 7：劇震
- 6：烈震
- 5：強震

各震區受影響之交通設施

Traffic system

各震區之交通設施

交通	設施
國道	國1、3、3甲
省道	台1、2、2甲、3、5、9、64
鐵道	高鐵、台鐵、捷運

震度分級
- 7：劇震
- 6：烈震
- 5：強震

各震區受影響人數

People affected

各震度影響人數

震度	數目
7	27 萬人
6	201 萬人
5	31 萬人

震度分級
- 7：劇震
- 6：烈震
- 5：強震

Scenario-based Maps

各震區可供收容公園
Parks for relief

各震度內公園

震度	數目
7	28 處
6	271 處
5	58 處

震度分級
- 7：劇震
- 6：烈震
- 5：強震

：公園

土壤液化潛勢區域
Soil Liquefaction

中、高潛勢區域

縣市	鄉鎮區
屏東縣	12
高雄市	15
台南市	7

潛勢分級
- 高潛勢
- 中潛勢

各震區與設施位置
Infrastructure

各震度之設施

震度	設施
6	松山機場、台北車站、內湖科技園區
5	南港軟體工業園區

震度分級
- 7：劇震
- 6：烈震
- 5：強震

中、高阻斷率的橋梁
Blocking-up Bridges

橋梁統計

縣市	橋梁
屏東縣	3

* 阻斷率≥50%

震度分級
- 6：烈震
- 5：強震
- 4：中震
- 3：弱震
- 2：輕震
- 1：微震

Assessment module

- Earthquake-induced landslide
- Soil liquefaction
- Building collapse and Casualties

Earthquake-induced landslide

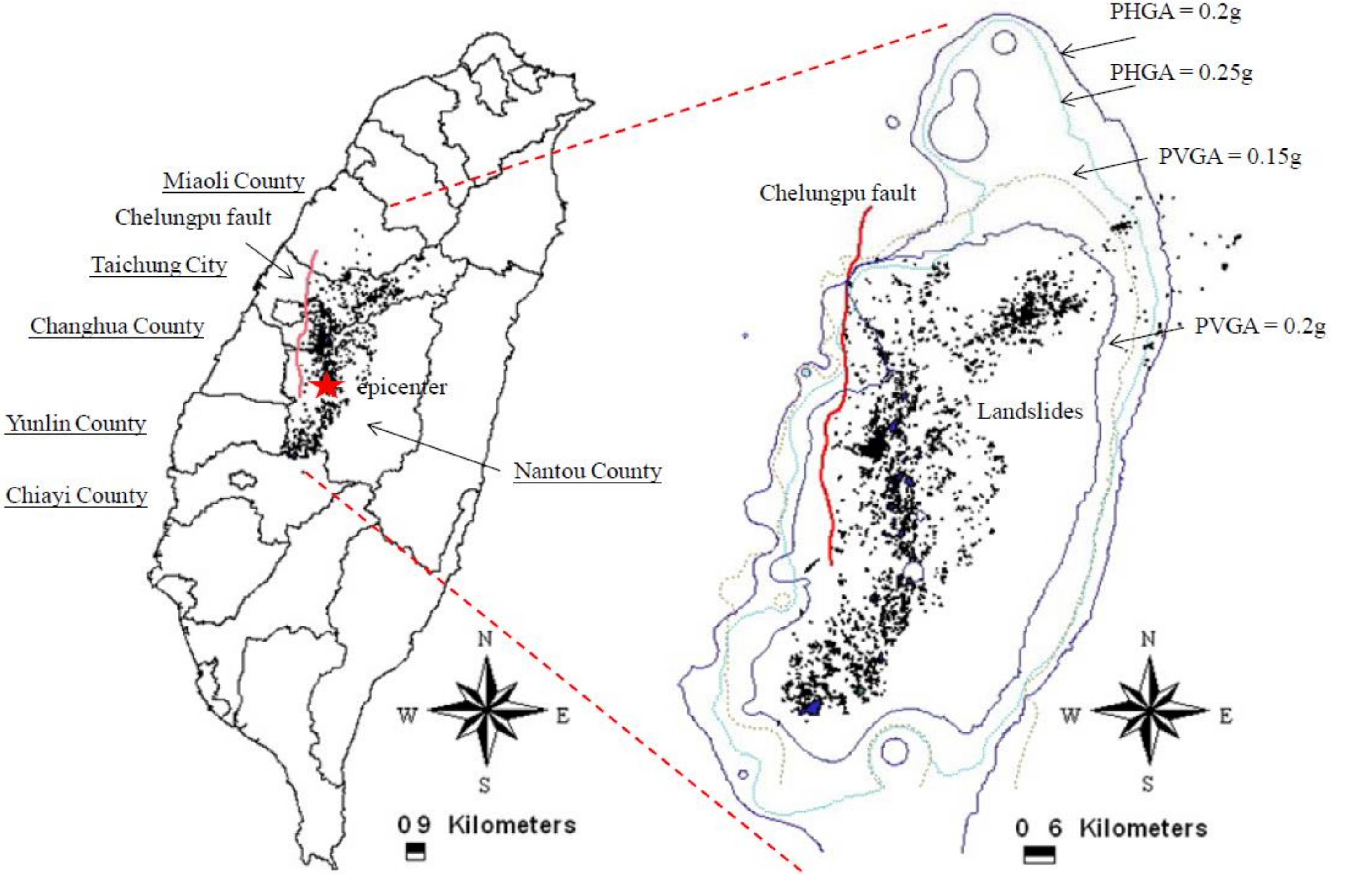


Figure 1 Site location of Chelungpu fault, isoseismal map of mean PHGA, PVGA and coseismic landslides during the Chi-Chi earthquake in 1999 (CGS 1999; SWCB 1999)

Huang et al. (2012)

Earthquake-induced landslide

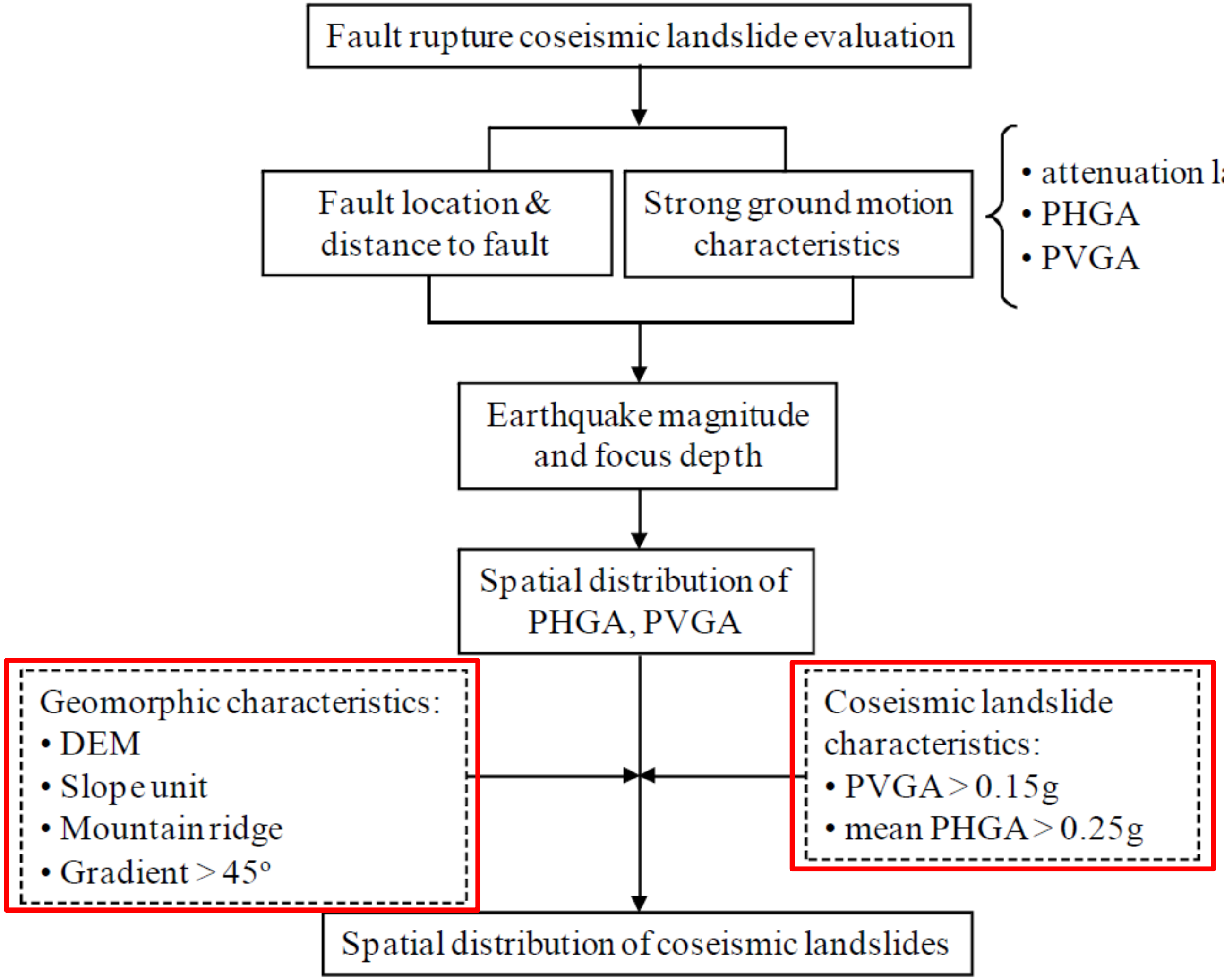


Figure 4 The flow chart for evaluation of the fault motion-induced coseismic landslides

Huang et al. (2012)

Earthquake-induced landslide

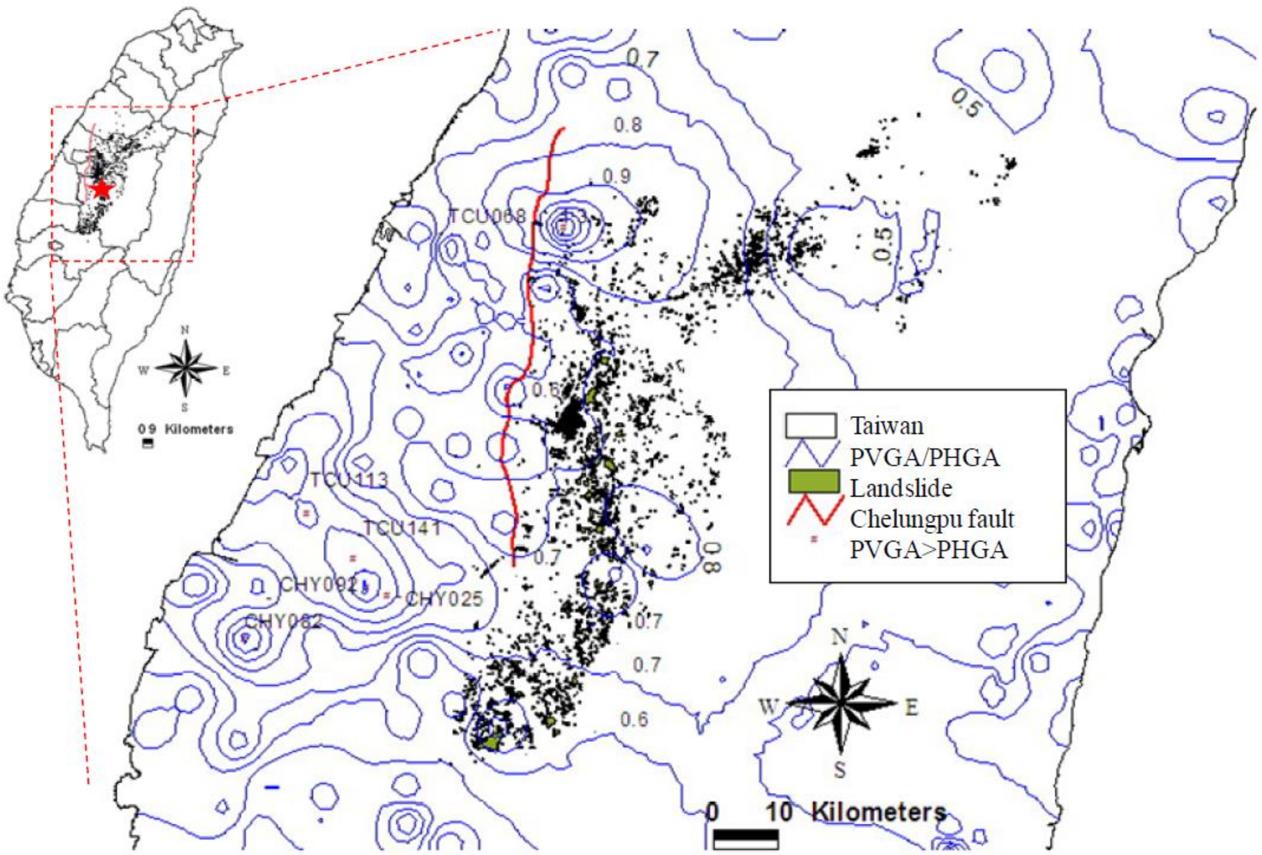


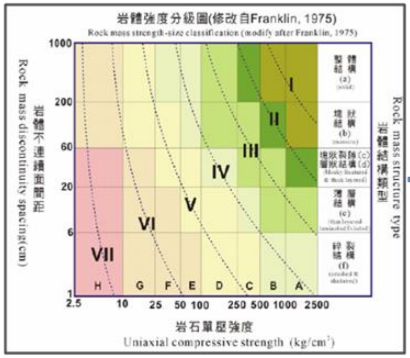
Figure 10 Contour of vertical accelerometric parameter and coseismic landslides during the Chi-Chi earthquake in 1999

Case study for the 1999 Chichi earthquake

Coseismic landslides are highly correlated with PGA of the horizontal and vertical components.

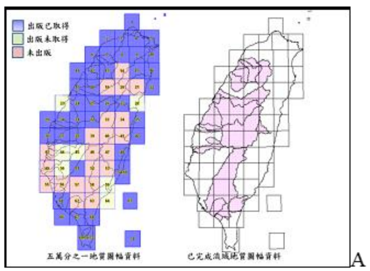
Huang et al. (2012)

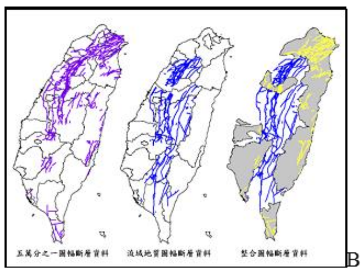
Earthquake-induced landslide

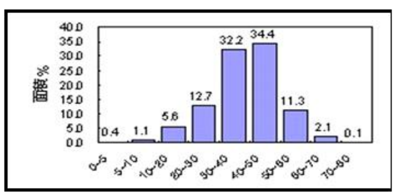


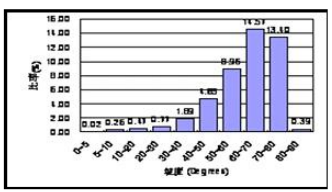
Rock/soil type

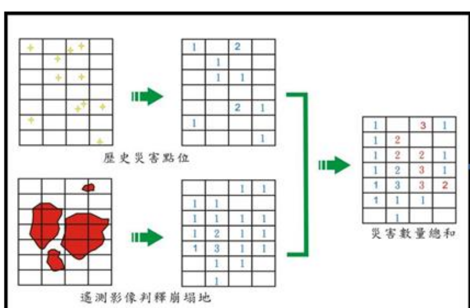
Geological structure







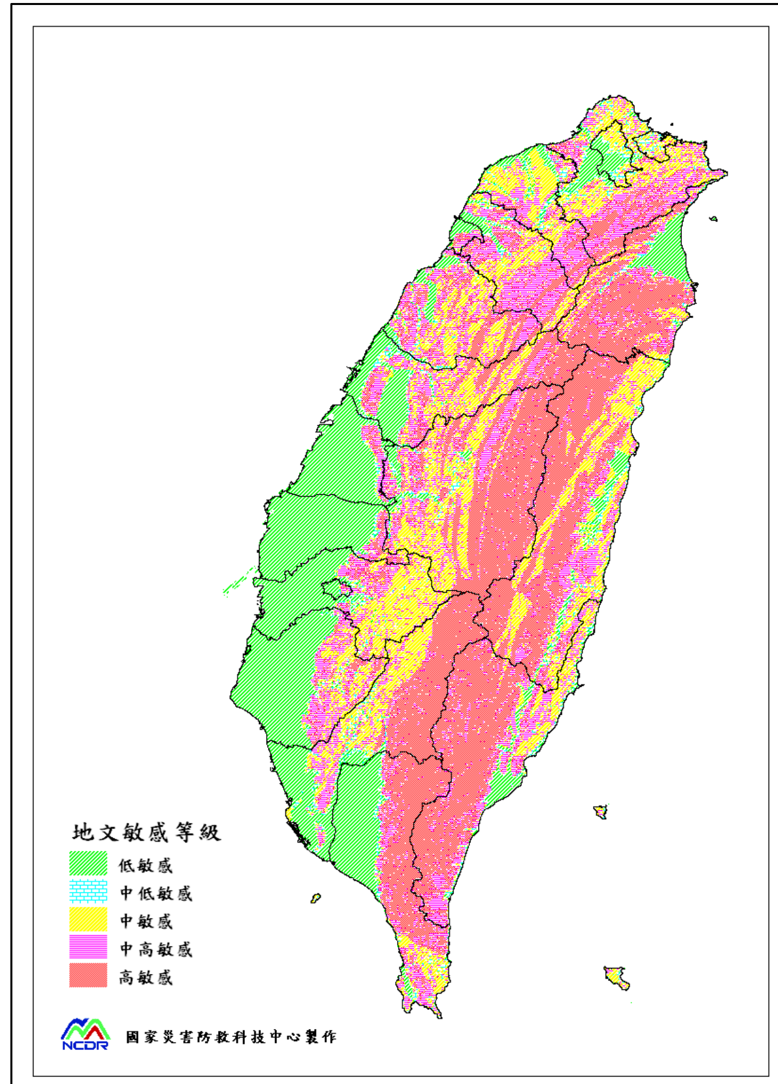




Topography (i.e., gradient, slope and area)

Historical disaster

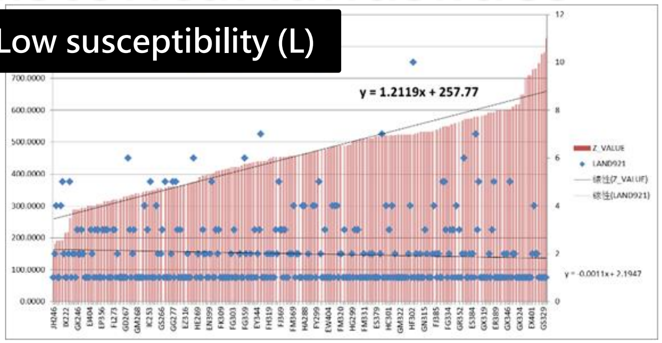
Susceptibility map of geology



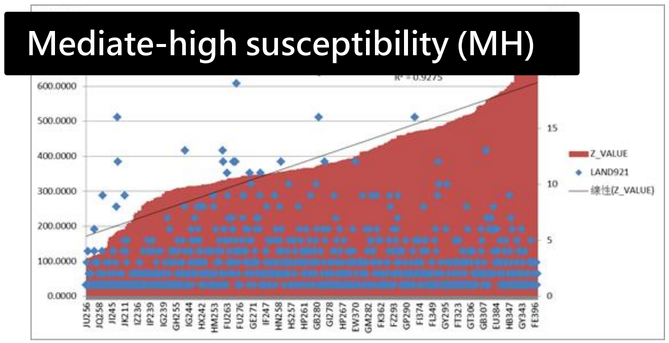
Earthquake-induced landslide

Correlation between geological susceptibility, PGA, and historical landslides

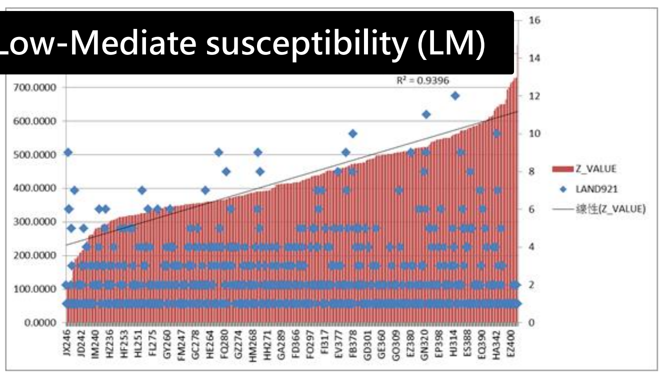
Low susceptibility (L)



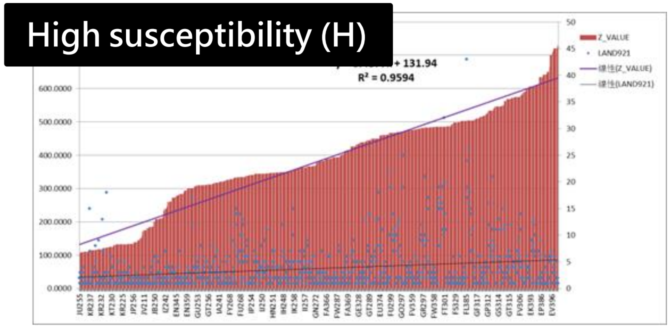
Mediate-high susceptibility (MH)



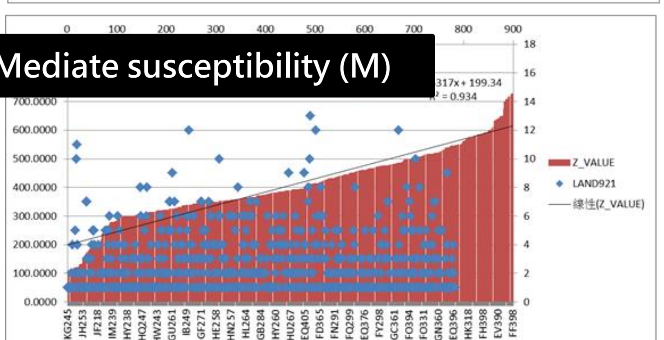
Low-Mediate susceptibility (LM)



High susceptibility (H)



Mediate susceptibility (M)



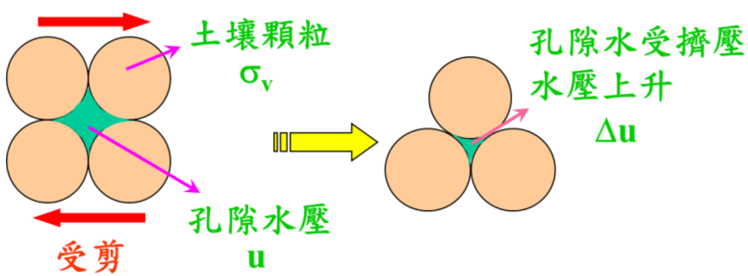
PGA thresholds for different levels of susceptibility

Level	L	LM	M	MH	H
PGA	250	230	195	170	130

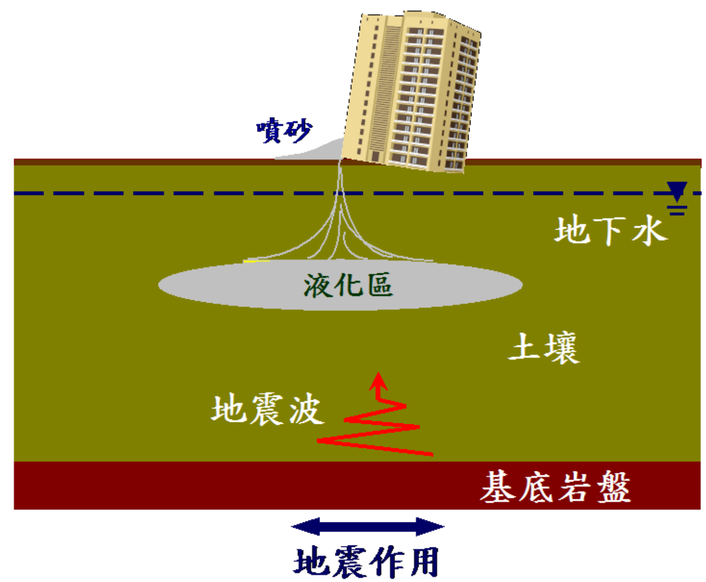
Earthquake-induced landslide

Soil liquefaction

Soil liquefaction describes a phenomenon whereby a saturated or partially saturated soil substantially loses strength and stiffness in response to an applied stress, usually earthquake shaking or other sudden change in stress condition, causing it to behave like a liquid.



$$\frac{\text{超額孔隙水壓}}{\text{覆土應力}} = \frac{\Delta u}{\sigma_v} = 1$$



Hazen, A. (1920). Transactions of the American Society of Civil Engineers. 83: 1717–1745

Soil liquefaction

The seismic design code of building in Taiwan , which is equivalent to the JRA(1996) method

Criteria of soil liquefaction analysis
(1)Depth of water table<10m, and depth of saturated sand layer<20m
(2)Fine content (FC)≦35%; or FC>35% and plastic index<15%
(3)Average particle size (D_{50})≦10mm, and 10% particle size (D_{10})≦1mm

Peak ground acceleration (cm/sec^2)

FC(%), D_{50}(mm), D_{10}(mm)

SPT-N

Effective overburden pressure σ'_v (kg/cm^2)

Cyclic shear stress ratio of stratum

$$L = r_d \times \frac{PGA}{g} \times \frac{\sigma_v}{\sigma'_v}$$

$$r_d = 1 - 0.015z$$

Cyclic shear strength ratio $R = c_w \times R_L$

$$R_L = 0.0882\sqrt{N_a/1.7} \qquad (Na<14)$$

$$R_L = 0.0882\sqrt{N_a/1.7} + 1.6\times10^6\times(N_a-14)^{4.5} \qquad (14 \leq Na)$$

Sand: $N_a = c_1 N_1 + c_2$ $\qquad N_1 = \frac{1.7\times N}{\sigma_v'+0.7}$

$$c_1 = \begin{cases} 1 & (0 \leq FC < 10\%) \\ (FC+40)/50 & (10\% \leq FC < 60\%) \\ (FC/20)-1 & (60\% \leq FC) \end{cases}$$

$$c_2 = \begin{cases} 0 & (0 \leq FC < 10\%) \\ (FC-10)/18 & (10\% \leq FC) \end{cases}$$

Factor of safety

$$F_L = \frac{R}{L}$$

Soil liquefaction

- **Liquefaction Potential**

$$P_L = \int_0^{20} F(z)w(z)dz$$

z: Depth 0~20m,

F_L: Factor of safety,

$F(z)=1-F_L$, for $F_L \le 1.0$,

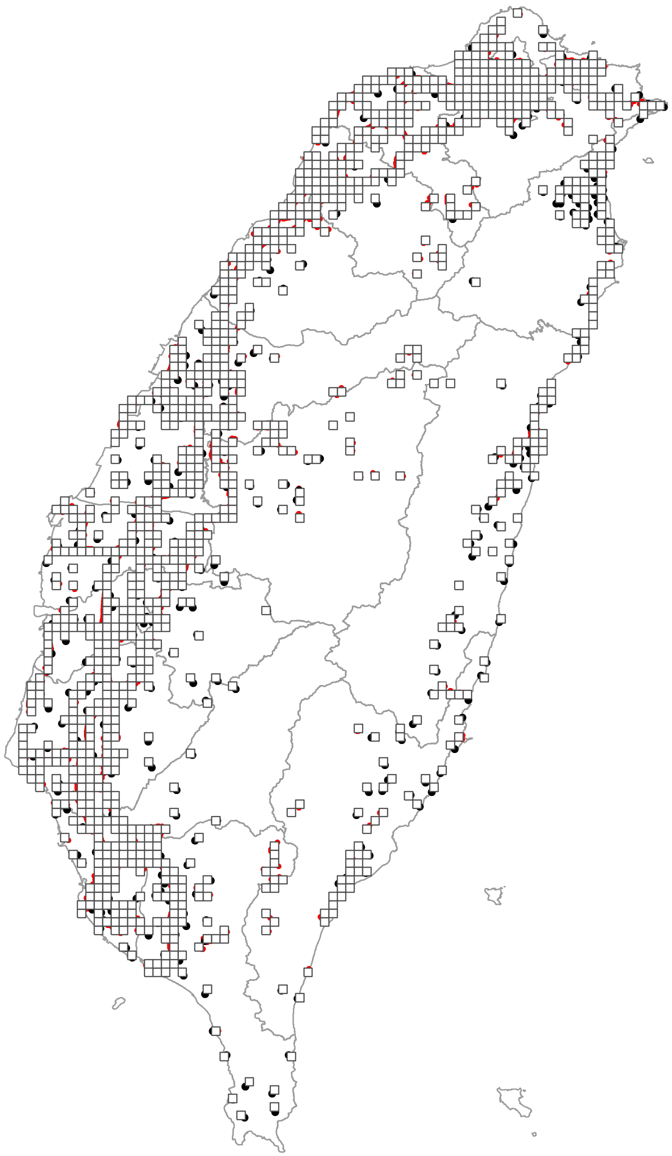
$F(z)=0.$, for $F_L > 1.0$

$w(z)=10-0.5z$

- **Three Categories**
  - $0 \le P_L < 5$: **low potential**; slight liquefaction
  - $5 \le P_L < 15$: **moderate potential**; settlement or liquefaction feature is not obvious on the ground surface; some liquefaction may be existed in deep layer of stratum.
  - $P_L > 15$: **high potential**; serious liquefaction; settlement or sand boiling is obvious on the ground surface

Iwasaki, 1982

Soil liquefaction



- Borehole data: 16,156
  1. The Geo2010 database established by the CGS which is mainly from the construction projects of infrastructures
  2. The engineering geological database of the strong-motion stations from the Central Weather Bureau (CWB)

Soil liquefaction

Damaged-prone buildings

DATA

Building' Data:

Structure type, age, design level, etc.

Design code of buildings:

1. Spectral acceleration
2. Site condition
3. Fault adjusting factor

Seismic resistance:

Fragility curve

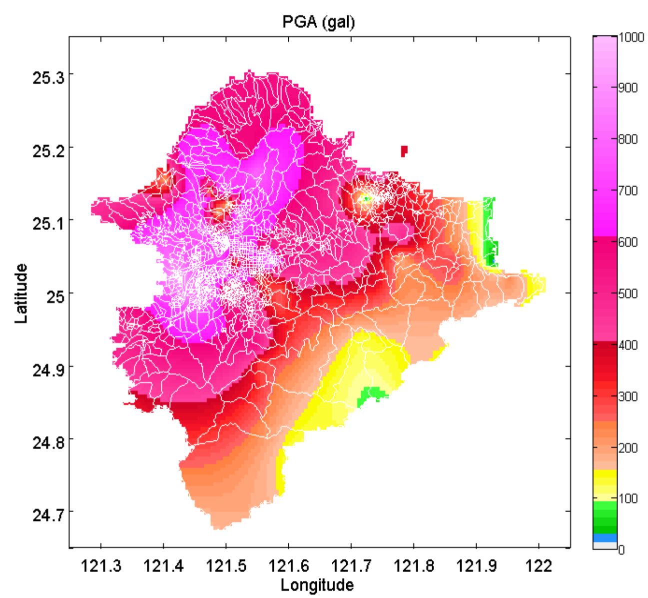
Calculation

Assessment：

Grid-based Fragility analysis

Input:

Peak ground acceleration (PGA)



Results

Damage Probability：

- 15 building types
- 4 design levels
- 4 probabilities

Buildings' damage into four categories:

Slight, moderate, extensive, complete

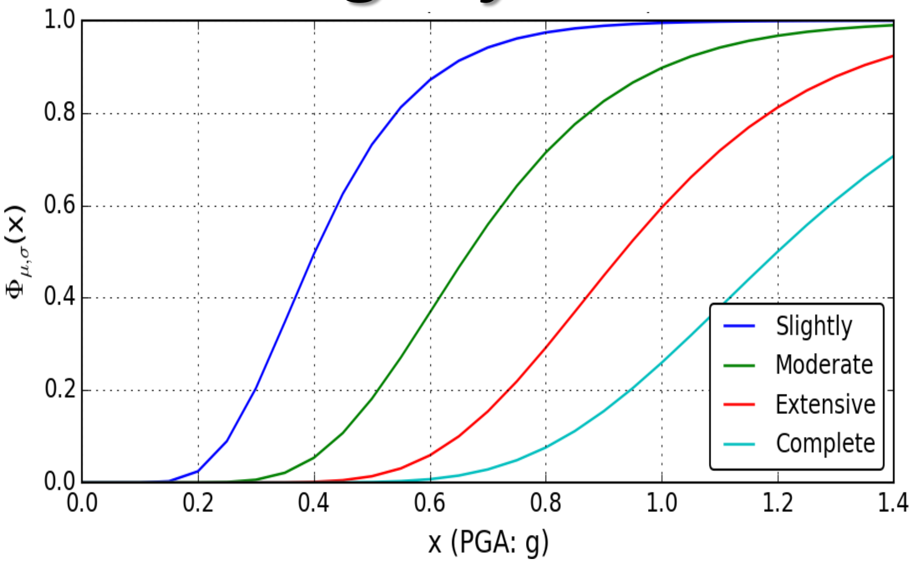
Yeh et al. (2006)

Damaged-prone buildings

Building types

結構型態分類 （TELES）		
1	W1	木造
2 3 4	S1L S1M S1H	鋼構造（低樓層:1~3層樓） 鋼構造（中樓層:4~7層樓） 鋼構造（高樓層:8層以上）
5	S3	輕鋼構（低樓層）
6 7 8	C1L C1M C1H	鋼筋混凝土構造（低樓層） 鋼筋混凝土構造（中樓層） 鋼筋混凝土構造（高樓層）
9	PCL	預鑄混凝土構造（低樓層）
10 11	RML RMM	加強磚造（低樓層） 加強磚造（中樓層）
12	URML	磚造（低樓層）
13 14 15	SRC1L SRC1M SRC1H	鋼骨鋼筋混凝土（低樓層） 鋼骨鋼筋混凝土（中樓層） 鋼骨鋼筋混凝土（高樓層）

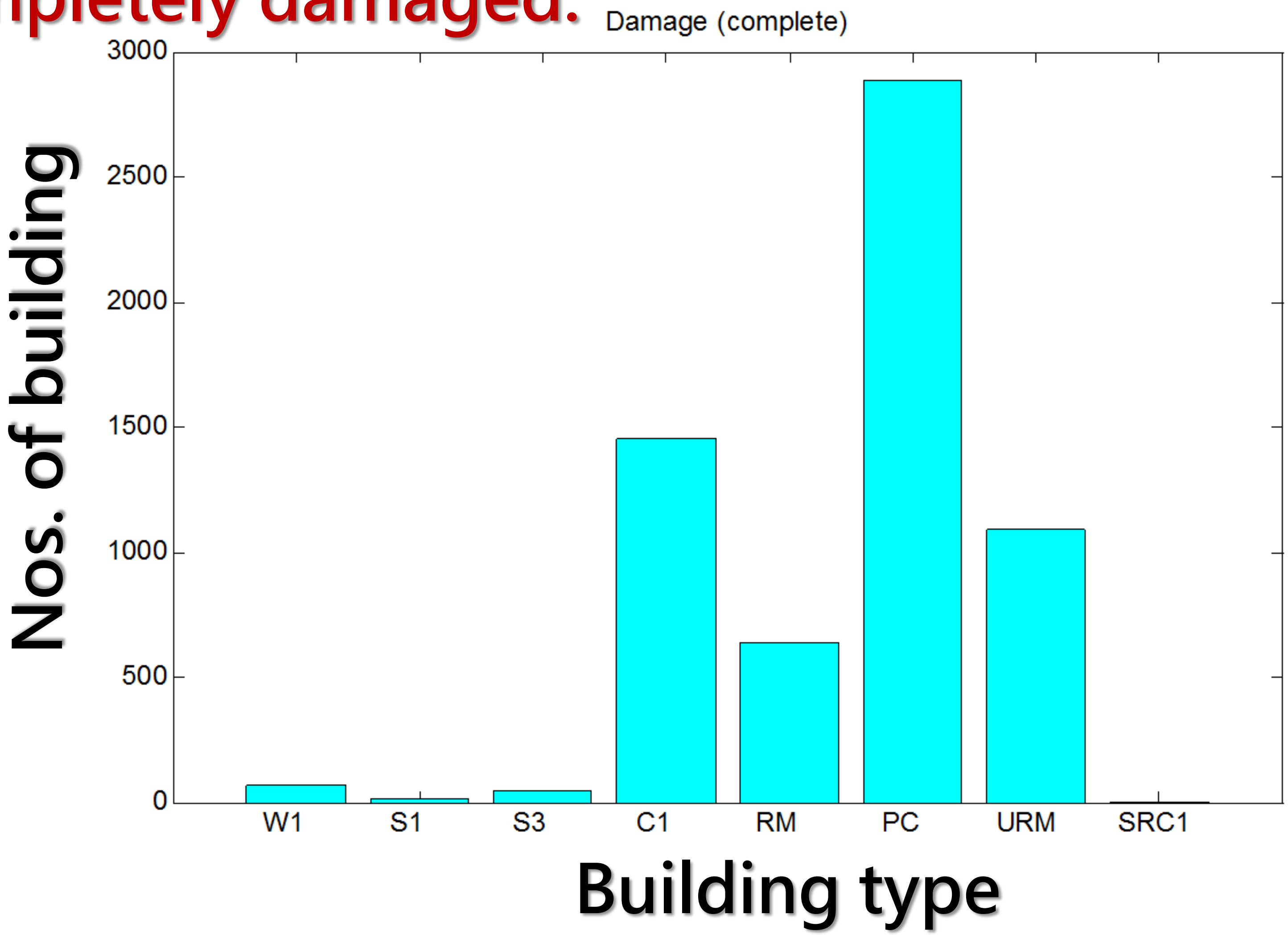
Fragility curve



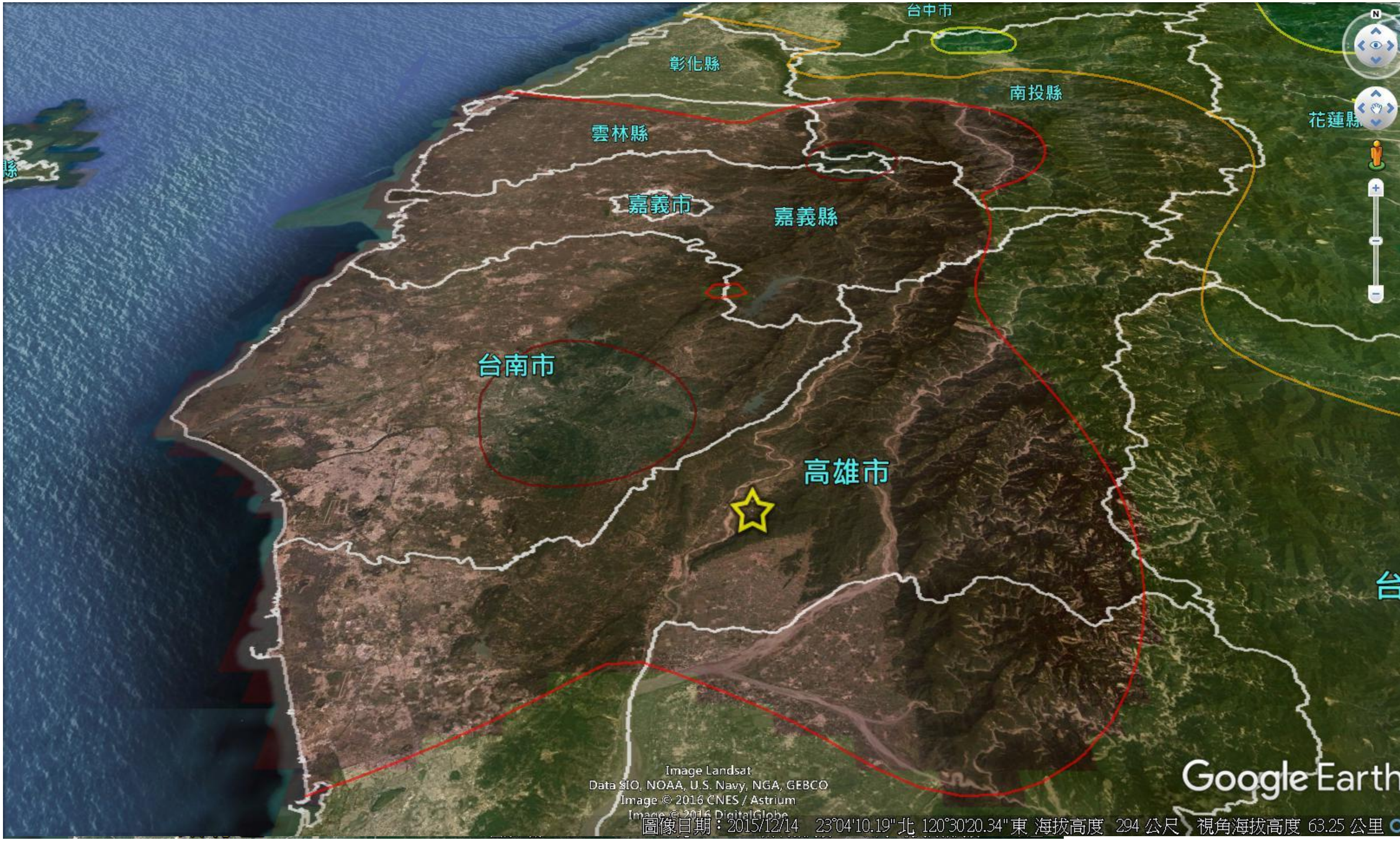
Yeh et al. (2006)

Damaged-prone buildings

For example: Buildings of different types are completely damaged.

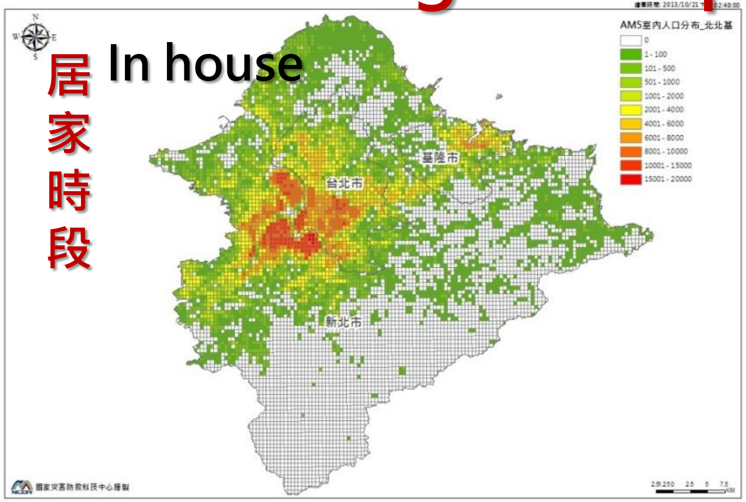


Damaged-prone buildings

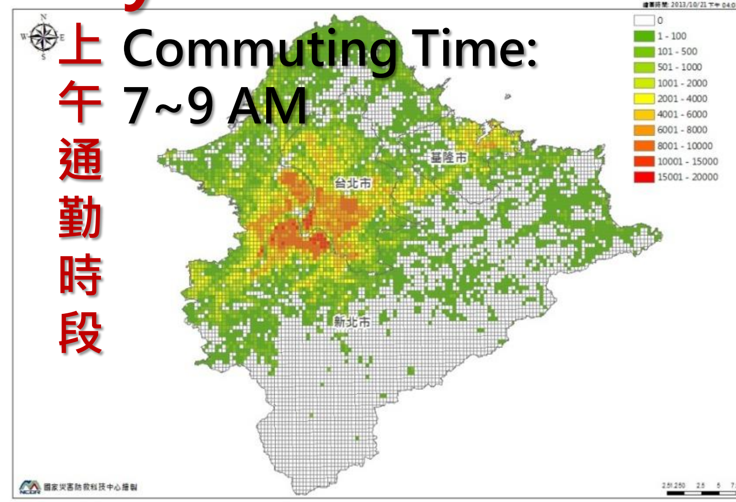


Casualty due to damaged building

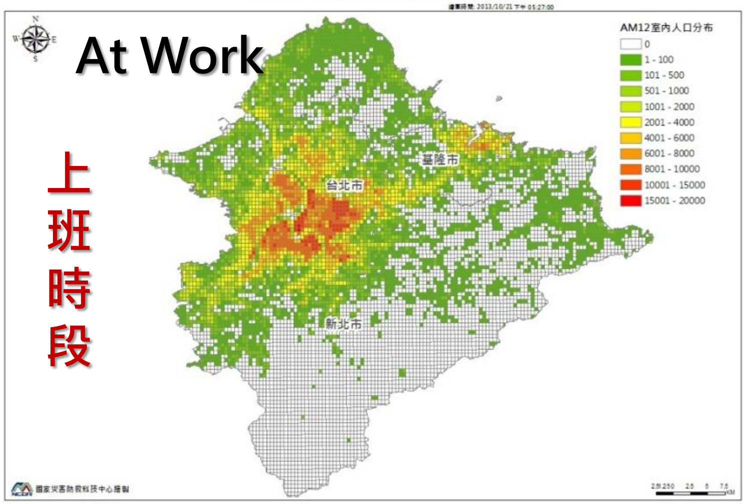
For example: distribution of population at four periods in buildings in Taipei city



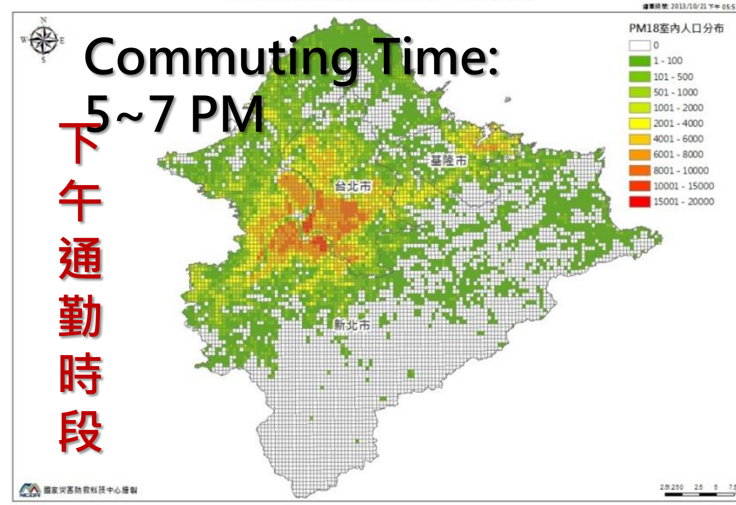
大台北地區室內人口分布模擬(上午通勤時段)



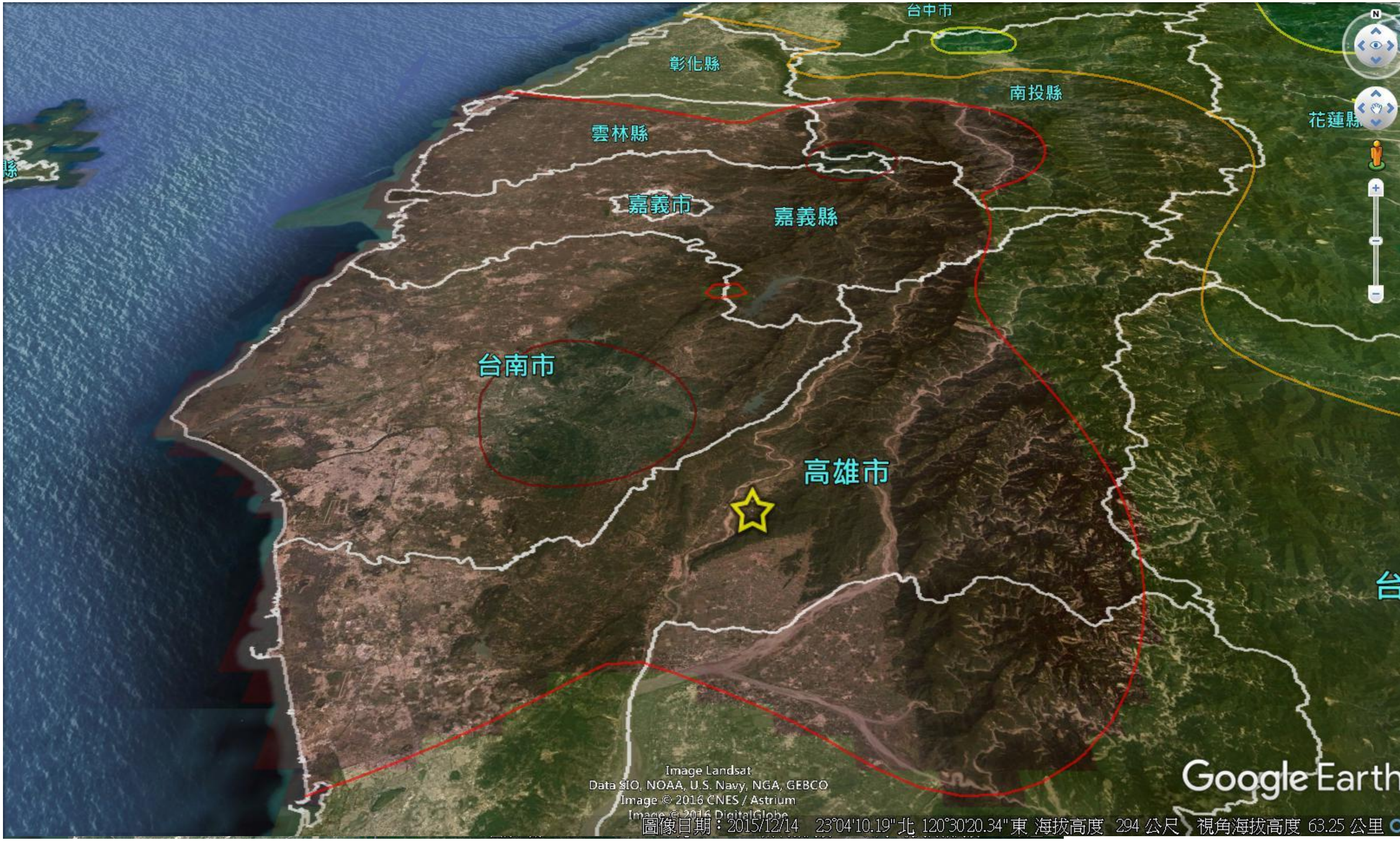
大台北地區室內人口分布模擬(上班時段)



大台北地區室內人口分布模擬(下午通勤時段)

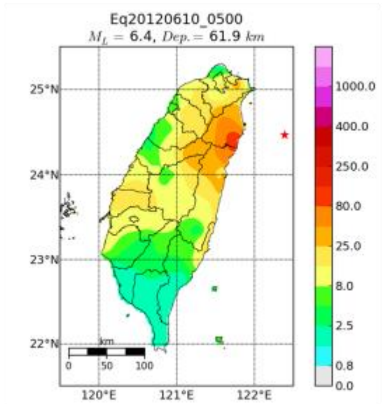


Casualty due to damaged building

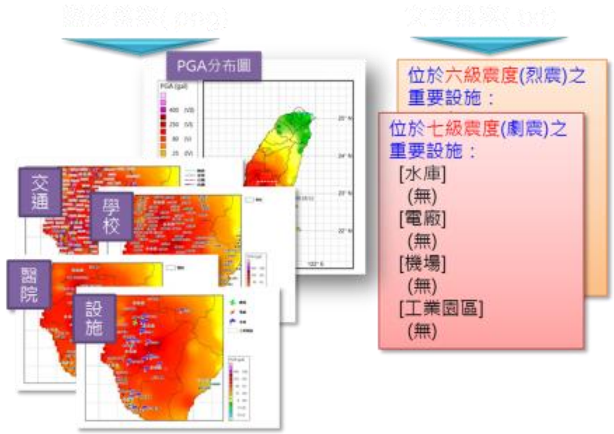


Implements (Tools) and Application

Info Dissemination after Earthquake



Grid-based PGA distribution



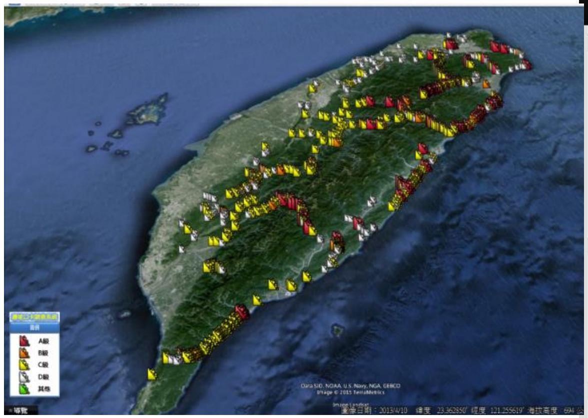
電子郵件簡訊內容*

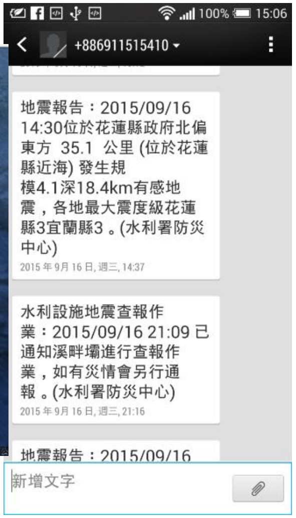
手機簡訊內容

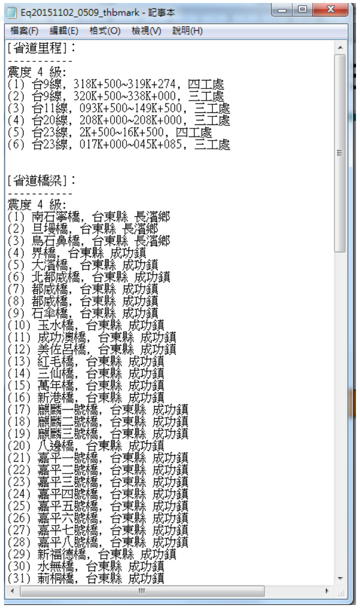
Dissemination via E-mail & cell phone

Users:

- Governments
- Water Resource Bureau
- The Highway Bureau
- NGOs
- Individuals






Eq20151102_0509_thbmark - 記事本

[省道里程]：

震度 4 級:
(1) 台9線, 318K+500~319K+274, 四工處
(2) 台9線, 320K+500~338K+000, 三工處
(3) 台11線, 093K+500~149K+500, 三工處
(4) 台20線, 208K+000~208K+000, 三工處
(5) 台23線, 2K+500~16K+500, 四工處
(6) 台23線, 017K+000~045K+085, 三工處

[省道橋梁]：

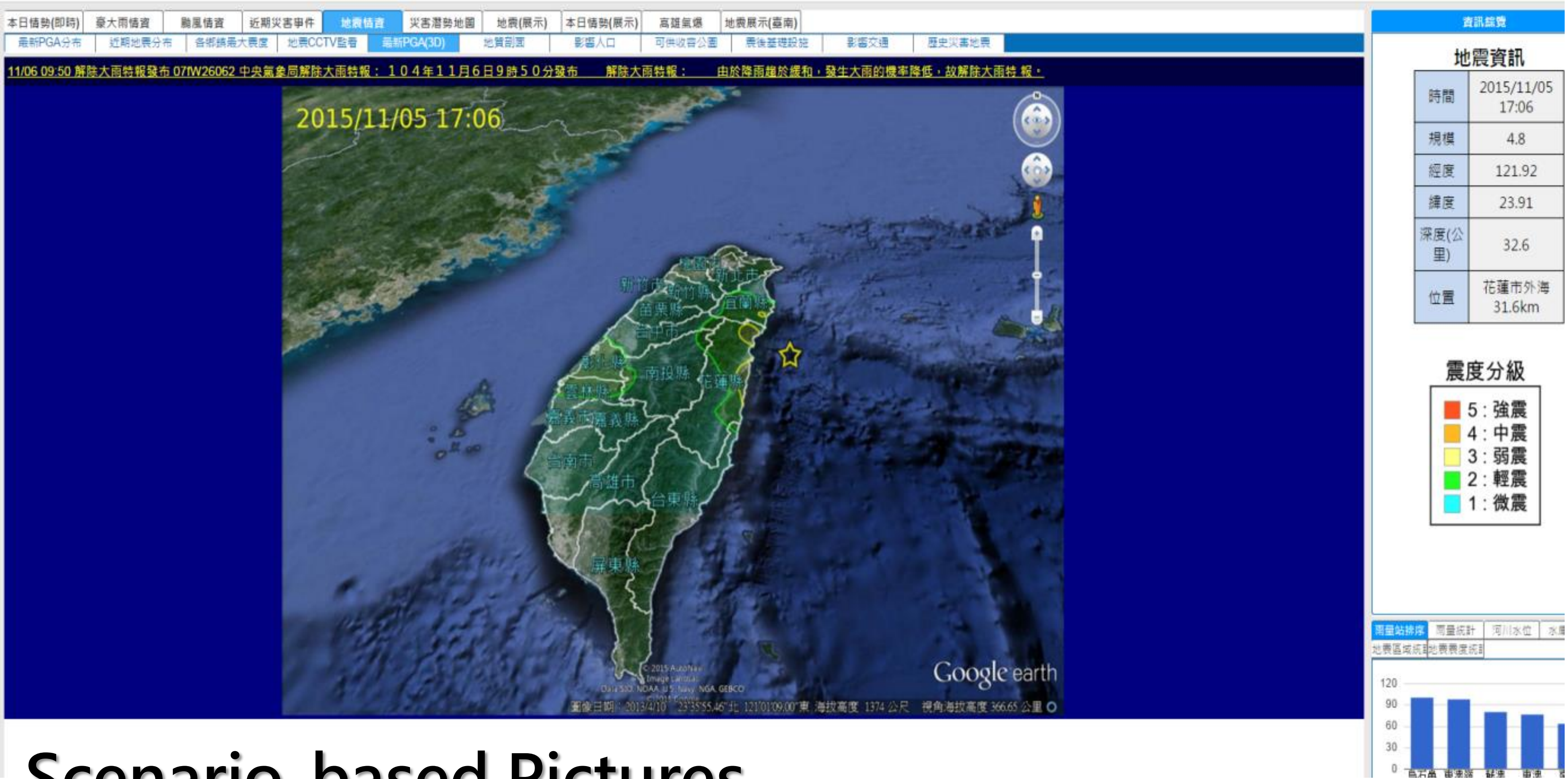
震度 4 級:
(1) 南石寧橋, 台東縣 長濱鄉
(2) 旦埸橋, 台東縣 長濱鄉
(3) 烏石鼻橋, 台東縣 長濱鄉
(4) 界橋, 台東縣 成功鎮
(5) 大濱橋, 台東縣 成功鎮
(6) 北都威橋, 台東縣 成功鎮
(7) 都威橋, 台東縣 成功鎮
(8) 都威橋, 台東縣 成功鎮
(9) 石傘橋, 台東縣 成功鎮
(10) 玉水橋, 台東縣 成功鎮
(11) 成功澳橋, 台東縣 成功鎮
(12) 美佐呂橋, 台東縣 成功鎮
(13) 紅毛橋, 台東縣 成功鎮
(14) 三仙橋, 台東縣 成功鎮
(15) 萬年橋, 台東縣 成功鎮
(16) 新港橋, 台東縣 成功鎮
(17) 麒麟一號橋, 台東縣 成功鎮
(18) 麒麟二號橋, 台東縣 成功鎮
(19) 麒麟三號橋, 台東縣 成功鎮
(20) 八邊橋, 台東縣 成功鎮
(21) 嘉平一號橋, 台東縣 成功鎮
(22) 嘉平二號橋, 台東縣 成功鎮
(23) 嘉平三號橋, 台東縣 成功鎮
(24) 嘉平四號橋, 台東縣 成功鎮
(25) 嘉平五號橋, 台東縣 成功鎮
(26) 嘉平六號橋, 台東縣 成功鎮
(27) 嘉平七號橋, 台東縣 成功鎮
(28) 嘉平八號橋, 台東縣 成功鎮
(29) 新福德橋, 台東縣 成功鎮
(30) 水無橋, 台東縣 成功鎮
(31) 莿桐橋, 台東縣 成功鎮

Earthquake Info to Central Government

- **NCDR provides scientific analysis and suggestions to support decision making at CEOC**

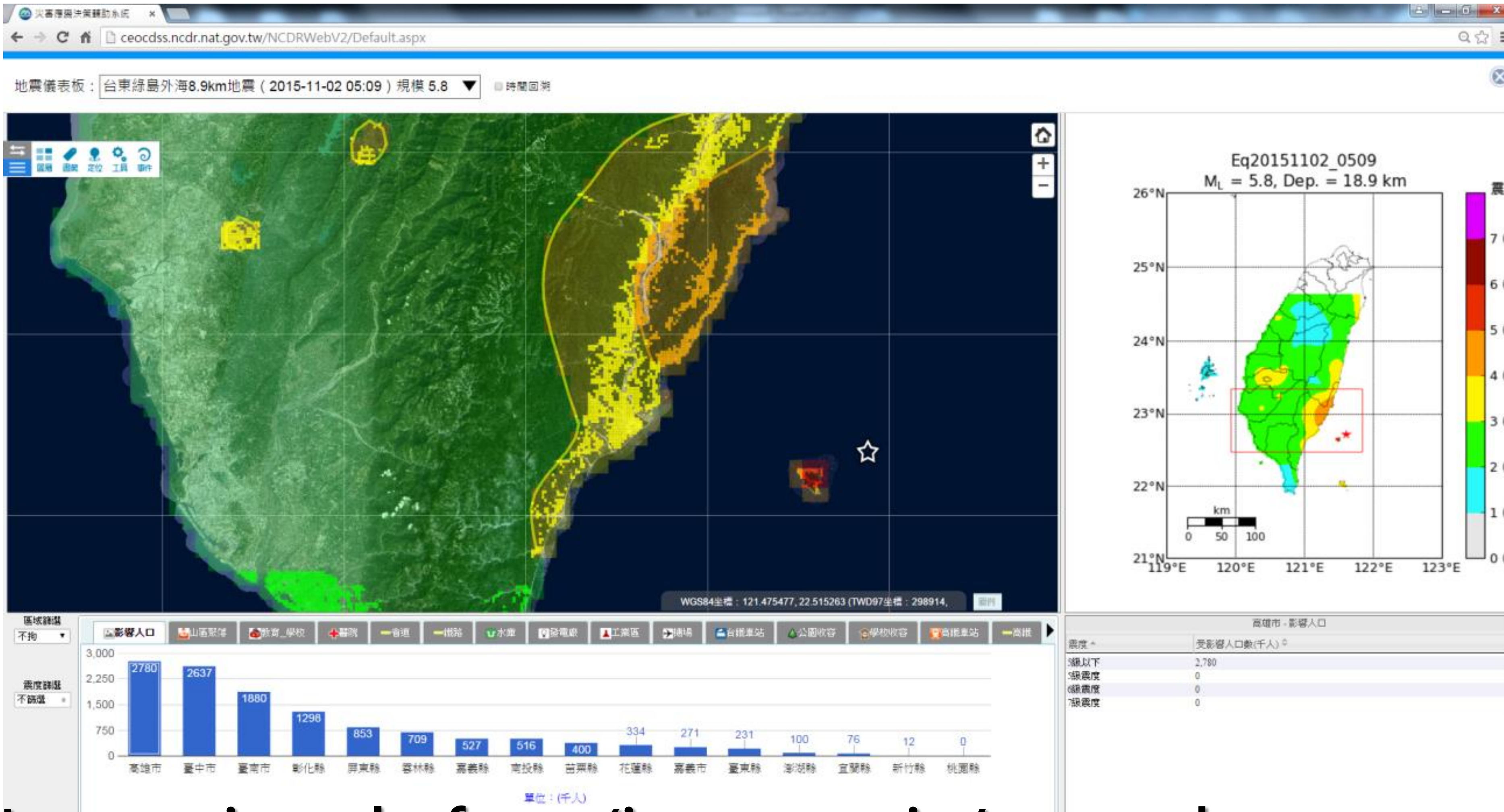
Earthquake Info to Local Government

NCDR's Decision Support System



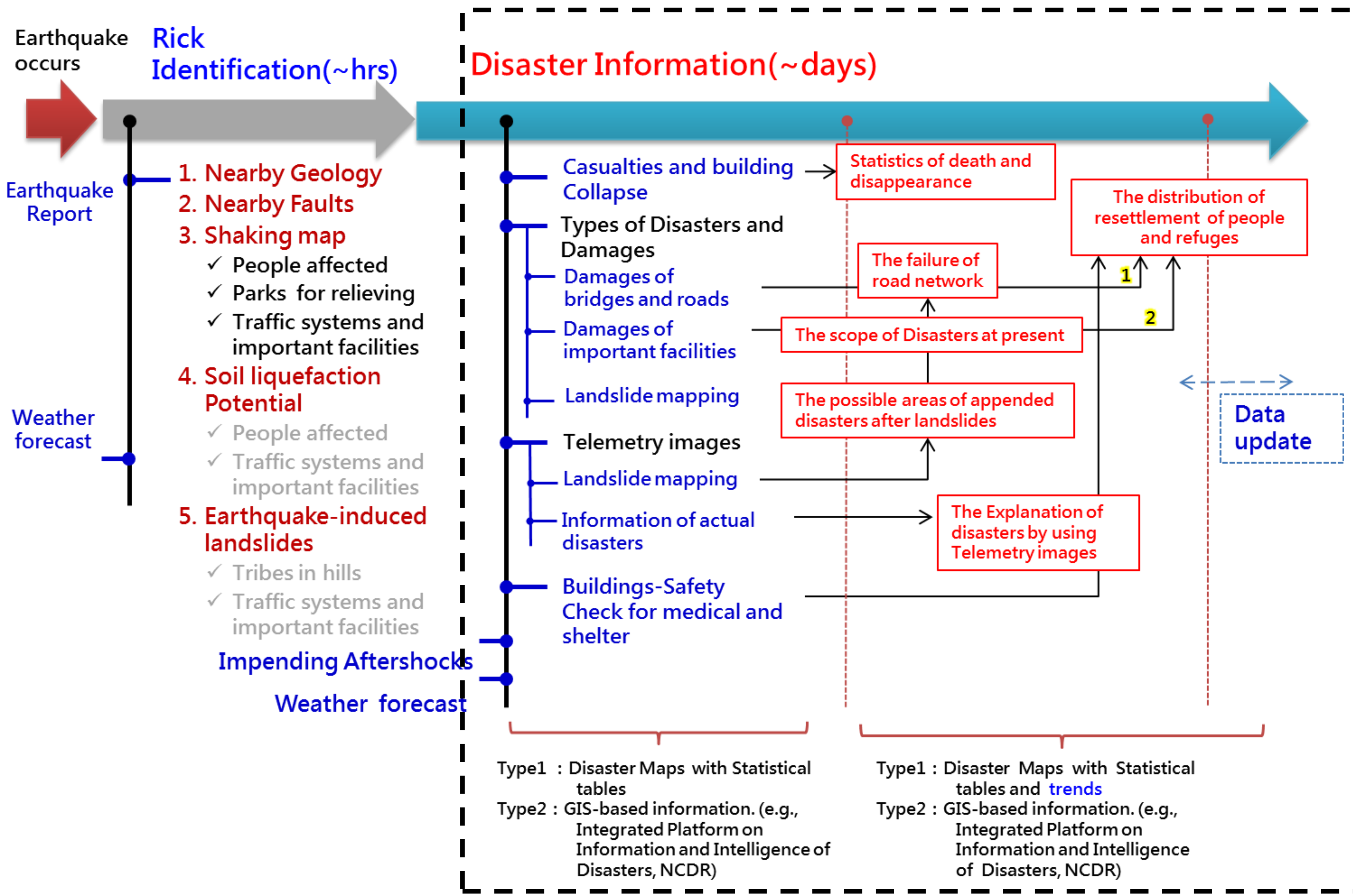
Scenario-based Pictures

Earthquake Info to Local Government



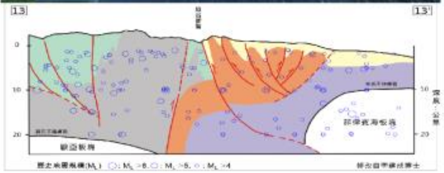
Interaction platform (i.e., room in/out and move focus)

NCDR Supports CEOC



Statistic disaster Maps for CEOC

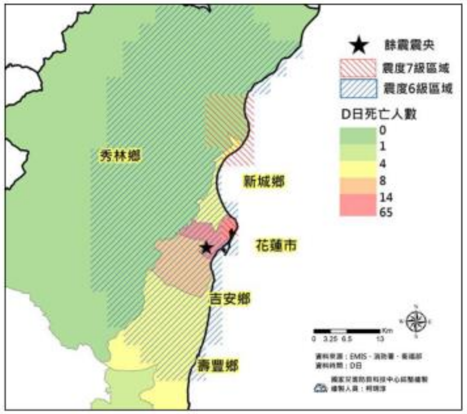
Aftershocks



餘震可能發生之位置

縣市	鄉鎮
花蓮縣	新城鄉、花蓮市 吉安鄉、壽豐鄉 鳳林鎮、豐濱鄉

Casualty

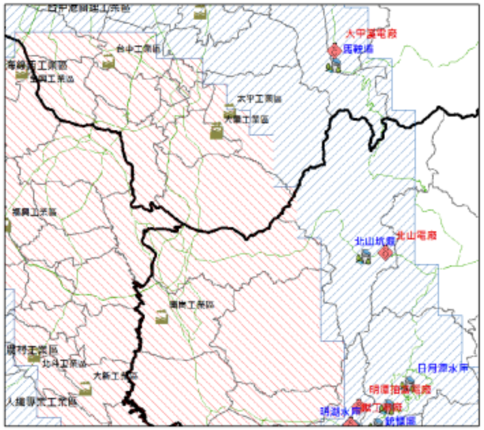


各縣市死亡人數統計

縣市	鄉鎮	D日死亡人數
花蓮縣	花蓮市	65
	吉安鄉	14
	新城鄉	8
	壽豐鄉	7
	光復鄉	4
	鳳林鎮	3
	秀林鄉	1
	豐濱鄉	0
	瑞穗鄉	0
宜蘭縣	羅東鎮	3
	宜蘭市	1
	蘇澳鎮	0

統計時間至D日17:00

Power deficiency



電力設施損壞

縣市	損壞 電力設施名稱
台中市	大甲溪發電廠
南投縣	北山電廠

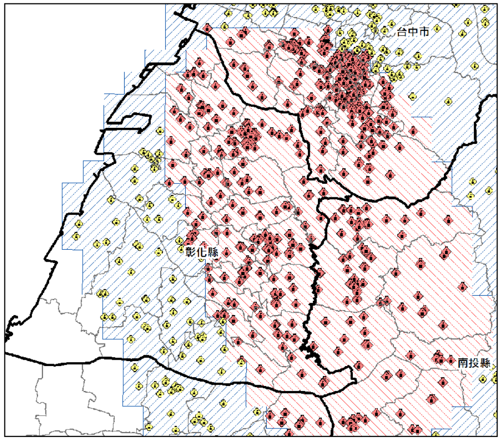
各縣市停電戶數

縣市	停電鄉鎮	停電 戶數
苗栗縣	南庄鄉、 三義鄉	600
台中市	全台中市	300,000
南投縣	集集鎮、 國姓鄉、 埔里鎮	5,000
彰化縣	芬園鎮、 彰化市	2,000

單位：戶

Statistic disaster Maps for CEOC

Schools in damage



校園受損統計（夜間）

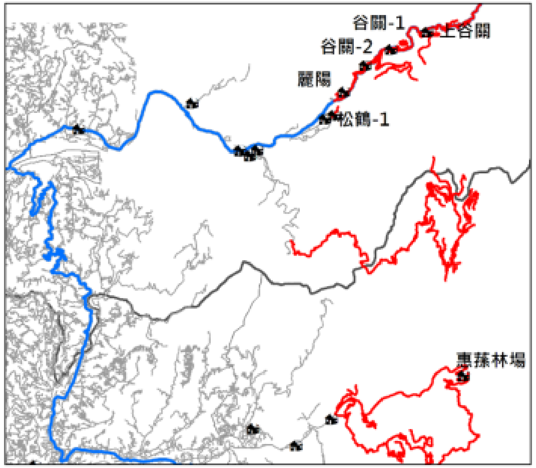
縣市	損毀學校	影響學生人數
	個	人
	個	人
	個	人

校園受損統計（日間）

縣市	損毀學校	影響學生人數	
		傷亡	疏散

統計時間至D日17:00

Tribes in hills

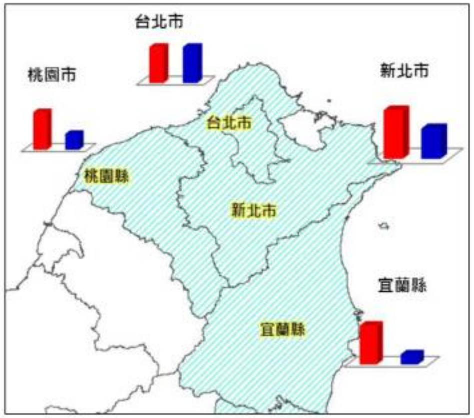


重要道路損壞

道路	中斷位置	可能為孤島部落	
台8	34.5K、64K	台中	上谷關青山
台14甲	2K、35K	南投	清境、梅峰
投91		南投	力行

統計時間至D日17:00

People in relief



各縣市疏散收容人數

縣市	疏散人數	收容人數
台北市	321	321
新北市	3,128	2,700
桃園市	1,200	492
宜蘭縣	20,700	5,003
花蓮縣	35,000	12,567

Comments for decision making

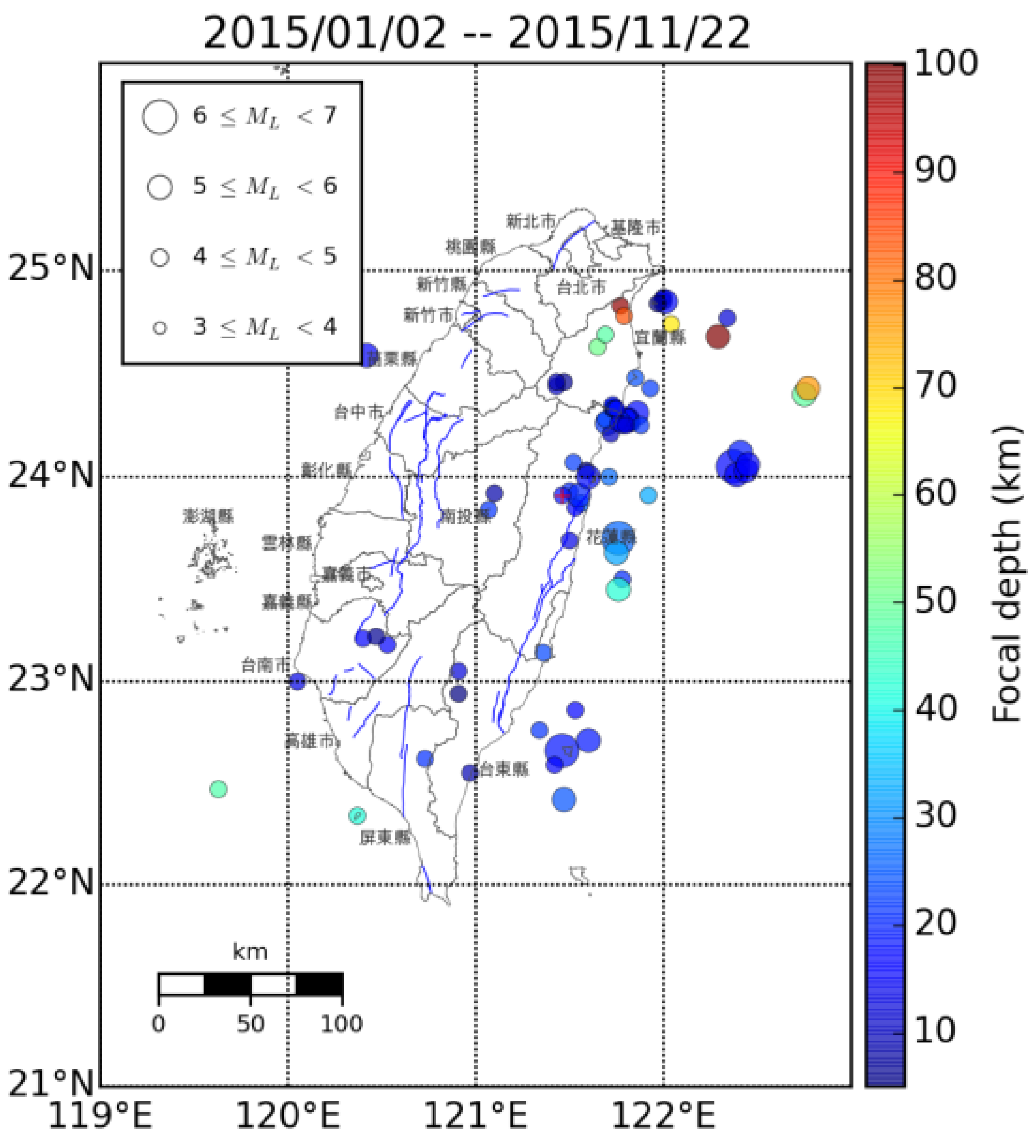
一. 地震資訊

1. 依據中央氣象局資料顯示強震區涵蓋新北市、台北市、桃園市，人口集中地區須優先進行安全查報，亦儘速確認各級行政單位是否持續運作

二. 災害預警資訊

1. 強震區內松山機場、台北車站、內湖科技園區、南港軟體工業園區，應儘速進行安全查報
2. 強震區內國1、3、3甲；台1、2、2甲、3、5、9、64；高鐵、台鐵、捷運，儘速確認交通功能，以利後續救援及物資調度作業

Information Dissemination Statistics: 2015



97
Earthquake Events

1067
Slides Sent

>35k
Units & individuals received

Future work

- Scenario Assessments
  - Improving Assessment Technology and tools: transportation, lifelines, infrastructure…

Assessment Automation