



14th South East Asia Survey Congress

Debris Flow Disaster Management under Climate Change Impact in Taiwan

Chen-Yang Lee, Hsiao-Yuan(Samuel) Yin Ph.D,

***Director, Debris Flow Disaster Prevention Center
Soil and Water Conservation Bureau, Council of Agriculture, Taiwan***

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Outline

- 1. Background Introduction***
- 2. Framework of Debris Flow Disaster Management***
- 3. Mechanism of Comprehensive Self Prevention and Protection***






Natural Hazards Risk Atlas

2014



| Rank | Country | Category |
|------|---------|----------|
| 1 | Japan | Extreme |
| 2 | USA | Extreme |
| 3 | Taiwan | Extreme |
| 4 | China | Extreme |
| 5 | India | Extreme |

| Rank | Country | Category |
|------|-------------|----------|
| 6 | Mexico | High |
| 7 | Philippines | High |
| 8 | Italy | High |
| 9 | Australia | High |
| 10 | Indonesia | Medium |

| Legend | |
|---|---------|
|  | Extreme |
|  | High |
|  | Medium |
|  | Low |
|  | No data |



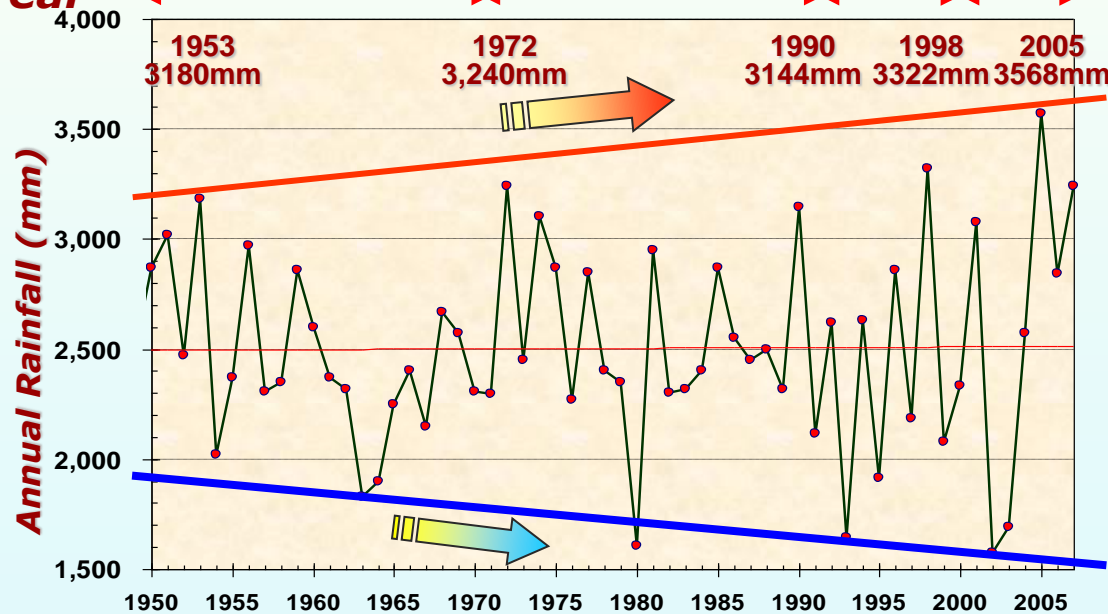
Climate Change Impact

Temperature increases about **1.4°C** in the last 100 years (1901-2006).

Variation of rainfall pattern of Taiwan in the past 50 years

Abundant Rainfall Year

19 yrs 18 yrs 8 yrs 7 yrs

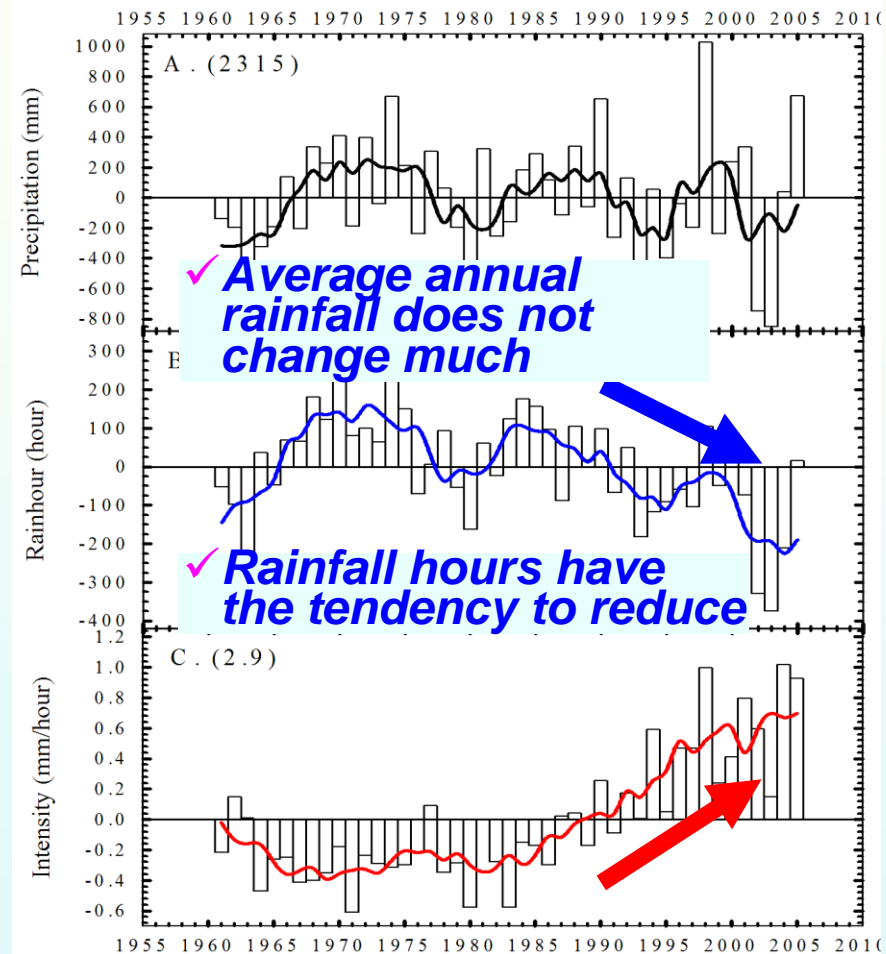


Drought Year

17 yrs 13 yrs 9 yrs

1963 1,830mm 1980 1,605mm 1993 1,645mm 2002 1,572mm

Average annual rainfall in the past 50 years



集集大地震

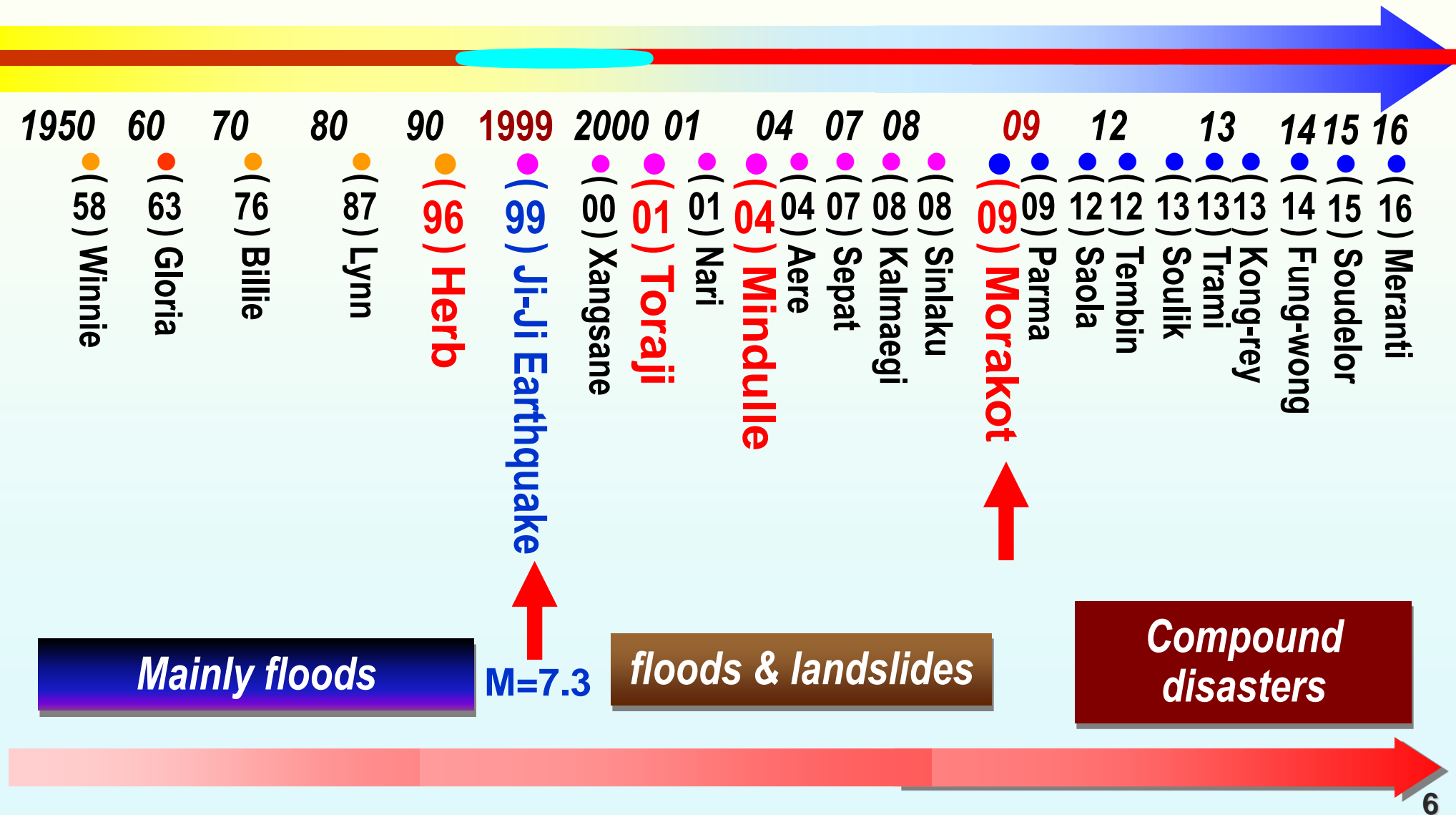
Sep. 21, 1999, Magnitude 7.3

(中央氣象局)

- Casualty : 2,415 people
- Missing : 29 people
- Wounded : 11,305 people
- Totally destroyed : 51,711 buildings
- Half destroyed : 53,768 buildings

JI-JI EARTHQUAKE

Historic Severe Typhoon Events in Taiwan



Debris Flow Disasters in Taiwan

1996-Herb



2004-Mindulle



**Debris flows caused by typhoon
Nanmadol in August, 2011**

**Source area
Landslides**

**Transportation part
Channel erosion**

**Deposition(fan) zone
Affected area**





2. Framework of Debris Flow Disaster Management

Potential Debris Flow Torrents

Debris Flow Warning Model

On-site Monitoring System

Debris Flow Information and Education

Framework of Debris Flow Management

Where?

How big (far) ?

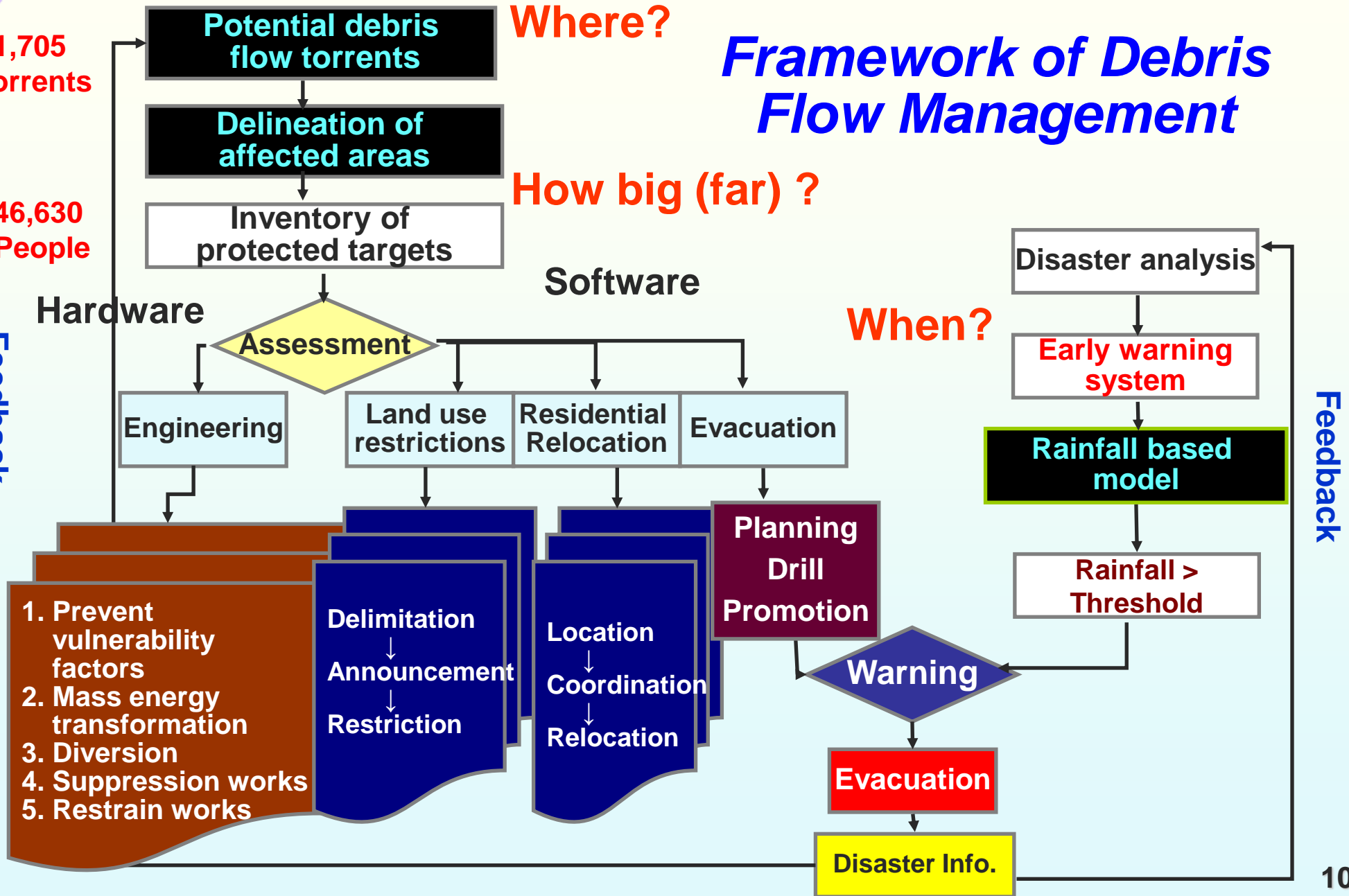
When?

1,705
Torrents

46,630
People

Feedback

Feedback



Identification of Potential Debris Flow Torrents

Risk Degree=Occurrence degree X

Degree of hazards on protected targets

Occurrence Degree

- ◆ Landslide ratio, drainage slope, sedimentation, geology, vegetation

Protected Targets

- ◆ Buildings, transportation facilities, watershed management performance

| Risk Degree | | Occurrence Degree | | |
|-------------------|------|-------------------|------|------|
| | | Low | Mid | High |
| Protected Targets | Low | Low | Low | Mid |
| | Mid | Low | Mid | High |
| | High | Mid | High | High |

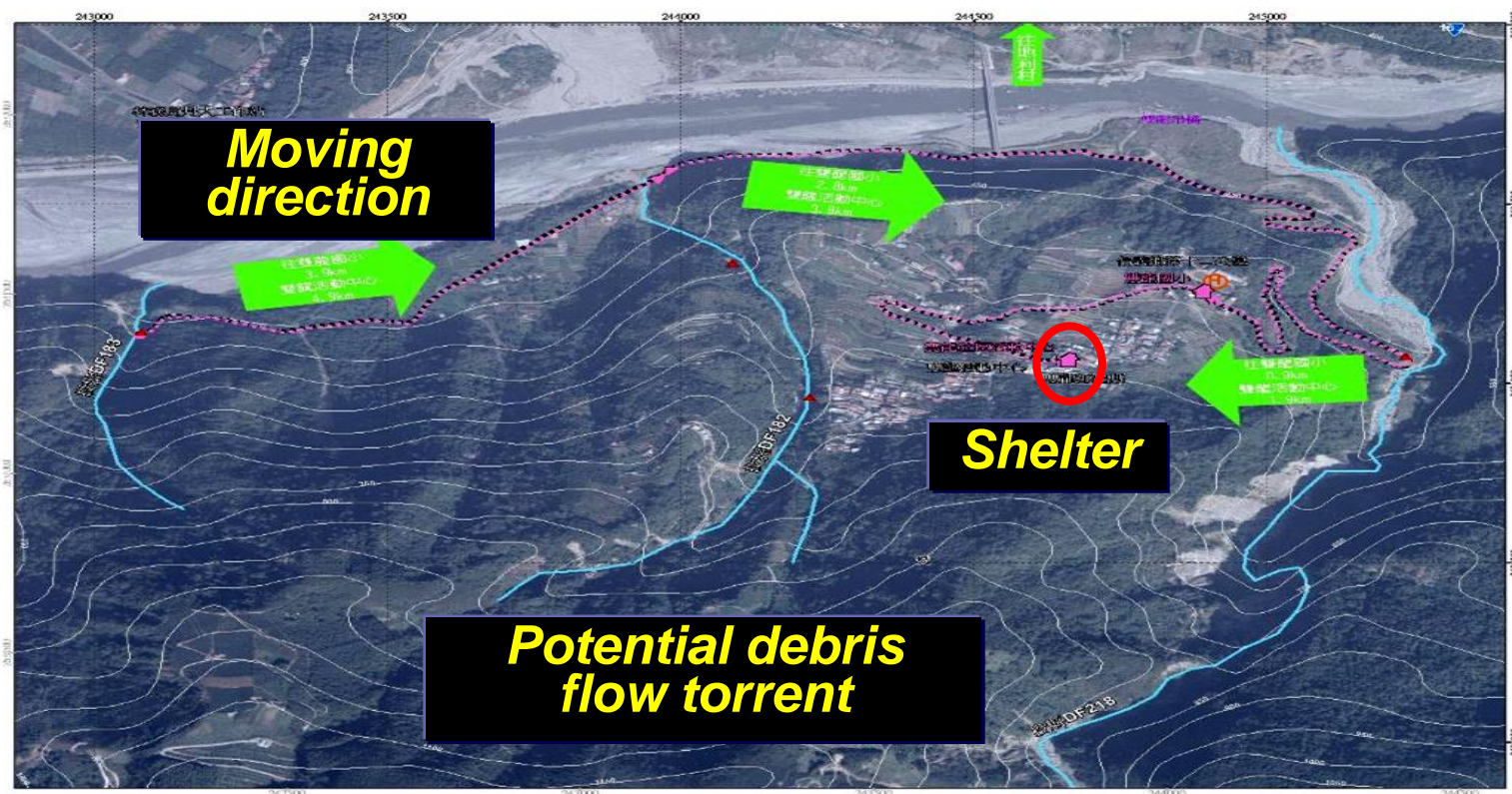


Preparedness for Evacuation

- 947 **Evacuation routes** planned
- 756 debris flow **evacuation drills** held

<http://246.swcb.gov.tw/>

Evacuation route map



災害通報單位

- 南投縣災害應變中心
電話：049-2206252#0
- 信義鄉災害應變中心
電話：049-2791515#130-131
- 水土保持局應變小組
電話：049-2347500
- 南投分局緊急應變小組
電話：049-2221847

緊急連絡人電話

- 村長：全得民
電話：049-2741318、0925-176095

避難處所

- 雙龍社區活動中心 (可容納人)
地址：信義鄉雙龍村光復巷16-1號
電話：0920-703550
- 雙龍國小 (可容納人)
地址：信義鄉雙龍村光復巷4號
電話：049-2741325

直升機起降點

- 直昇機起降點
地址：信義鄉雙龍村
電話：049-2333333

警消警察單位

- 信義消防分隊
地址：信義鄉明德街50號
電話：049-2791760
- 雙龍派出所
地址：信義鄉雙龍村光復巷33號
電話：049-2741321
- 雙龍村衛生室
地址：信義鄉雙龍村光復巷34號
電話：049-2741849
- 信義鄉衛生所
地址：信義鄉明德村玉山路45號
電話：049-2791148
- 竹山秀傳醫院
地址：竹山鎮集山路二段75號
電話：049-2624266

土石流警戒基準值：250mm

Shelter info

圖例

- ▲ 避難處所
- 直升機起降點
- △ 土石流警戒標誌位置

Localized Rainfall-based Debris-flow Warning Model

- **Rainfall Triggering Index (RTI)**
 = Rainfall intensity \times Effective accumulated rainfall

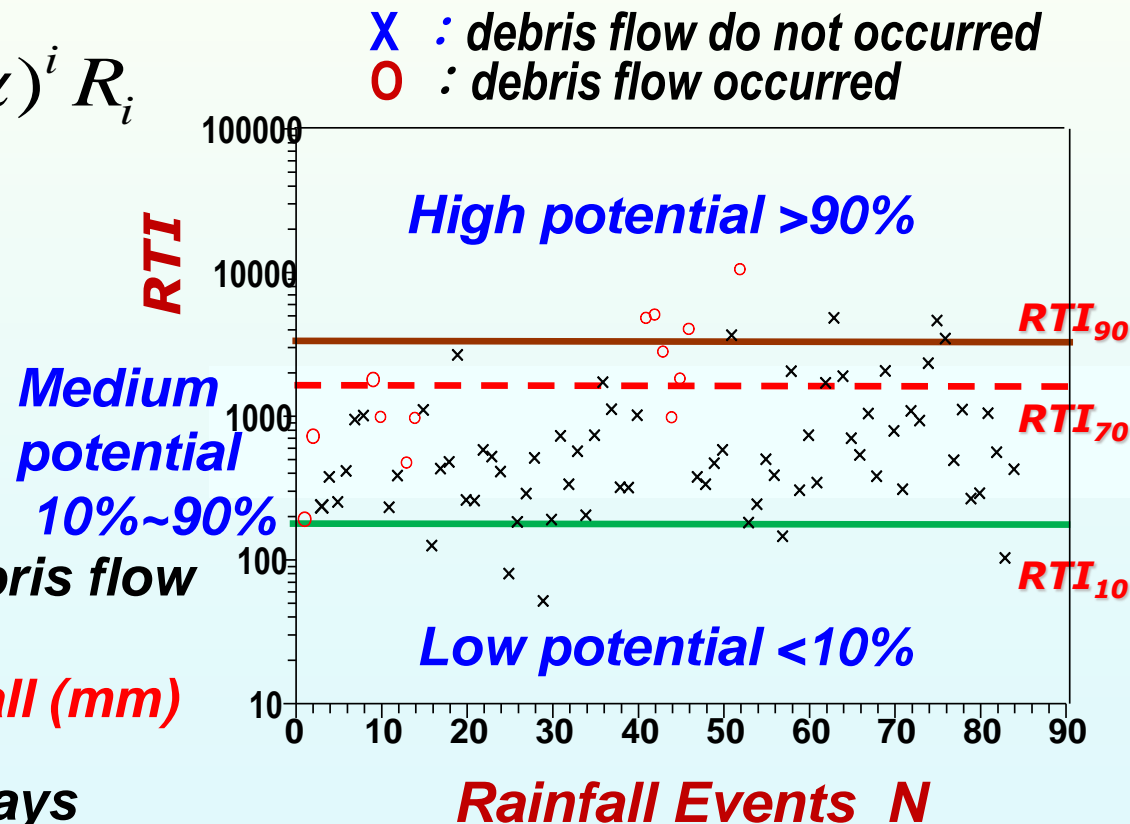
$$RTI = I \times R_t \quad R_t = \sum_{i=0}^7 (\alpha)^i R_i$$

α is the decaying weighting factor = 0.7

I : Rainfall intensity (mm/hr)

RTI_{70} : 70% RTI value as the debris flow warning criteria

R_t : Effective accumulated rainfall (mm)
 = Accumulated rainfall
 + Preceding rainfall for 7 days



Debris Flow Warning Stages

■ **Rainfall Threshold for Debris Flow Warning : 200~600mm**

Predict rainfall > Threshold

Real rainfall > Threshold

Accumulated rainfall

-30hr.

-18hr.

-12hr.

Sea typhoon alarm

Sea & land typhoon alarm

Yellow Warning

Red Warning

Rainfall forecast

Local government should **Advise** the inhabitants to evacuate.

Persuasive Evacuation

Enforced Evacuation

Local government should **Force** the inhabitants to evacuate.

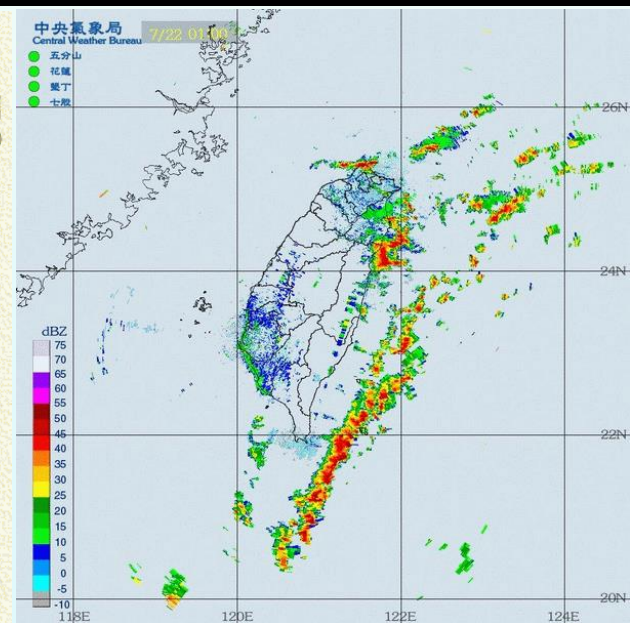
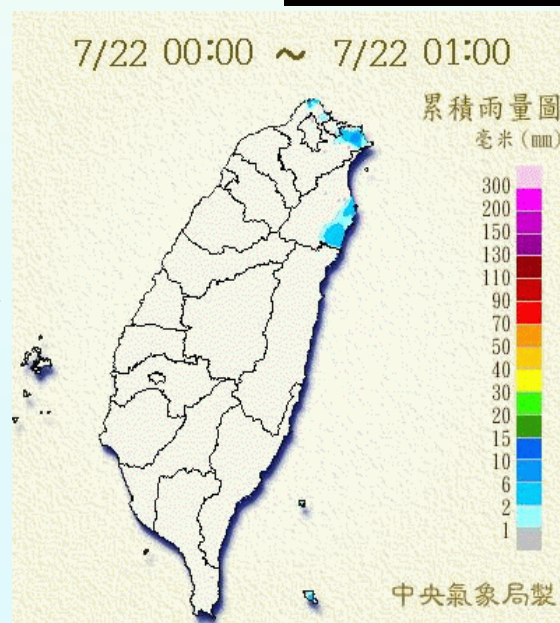


Debris Flow Emergency Operation Task Force of SWCB

<http://fema.swcb.gov.tw>

- Real-time weather condition: typhoon route and rainfall prediction
- Real-time rainfall data over **497** on-site auto-rain-gauges: refresh every 10 min
- **Debris flow warning** announcement

Traditional: TV news, radio broadcast, website, telephone,
Auto-system: email sender, on-line fax, voice broadcast and short message service



On-site Debris Flow Monitoring



3 Mobile stations



Display through
DDMI system and APPs
<http://246.swcb.gov.tw/>



21 Fixed stations

Communication



On-site Debris Flow Monitoring

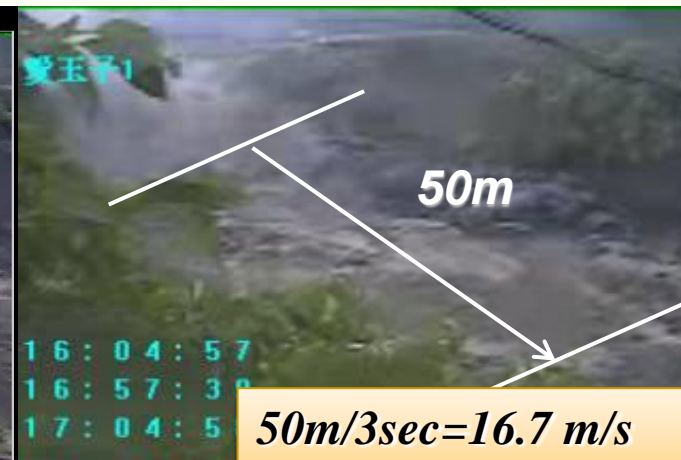


Typhoon Morakot, Aug. 8, 2009

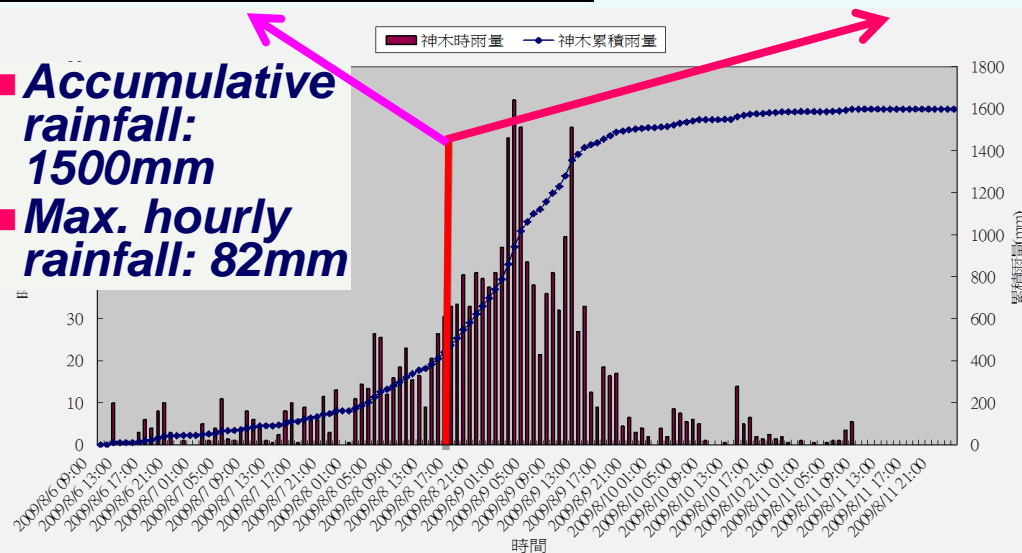
CCD image (front view)
downstream

CCD image (side view)
upper stream

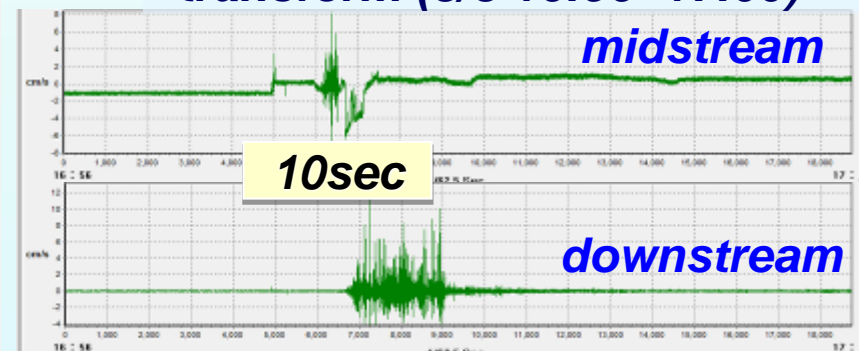
Velocity



- Accumulative rainfall: 1500mm
- Max. hourly rainfall: 82mm



- Geophone signal after wavelet transform (8/8 16:56~17:00)



$$173\text{m} / 10\text{sec} = 17\text{m/s}$$



Debris Flows Observation Data

Torrential rain in Shenmu monitoring station, 20 May, 2014



Seismometer signals are about **4 min**
ahead of geophone signals

Geophone initiated at 12:53:43

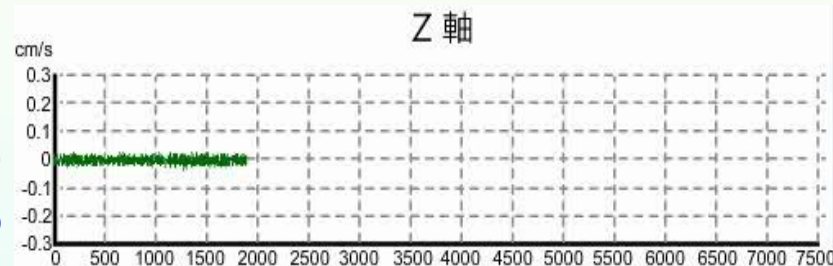
Wires broke at 12:53:44

Upstream, $I=54$ mm/hr, $R=58.5$ mm

Downstream, $I=24.5$ mm/hr, $R=26$ mm

Front surge velocity = 4.9 m/s

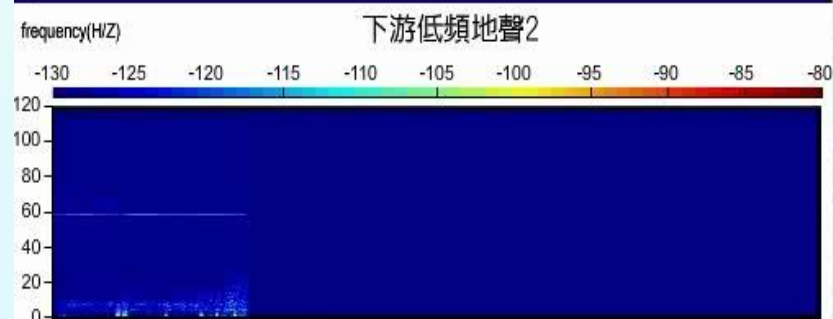
geophone



seismometer



spectrum



Evolution of mobile station



土石流觀測示範站
Mobile Landslide Observation Demonstration Station (SLDS)



行動式土石流觀測車





17 Portable monitoring station (since 2010)



On-line Event-database of Sediment-related Disasters

using UAV, satellite images and field investigation



On-line Education of Debris Flow Knowledge

Education videos uploaded on Youtube



防災利器 防災背包介紹



Disaster prevention knowledge



Parent-child interactive website

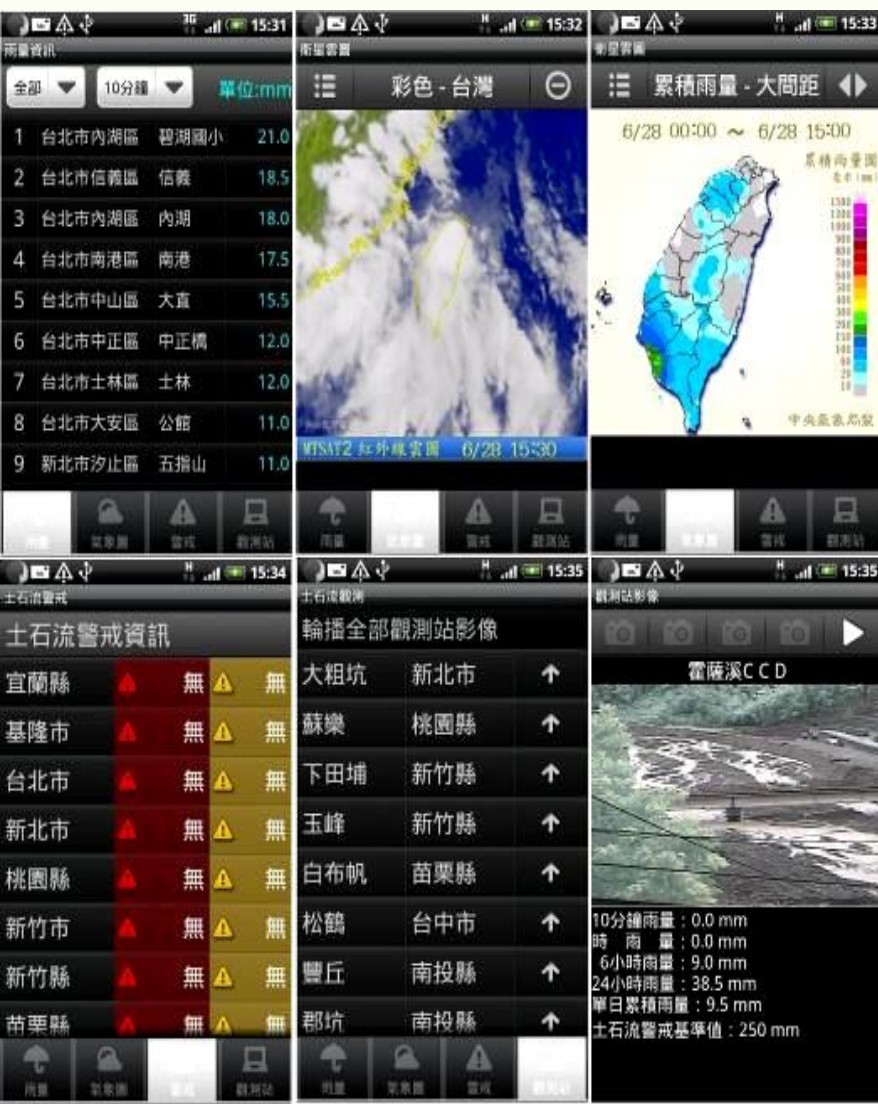


On-line monopoly game for disaster prevention

Apps for Debris Flow Prevention

Google map application

iOS
Android



雨量站站名：大坑

地區：台中市北屯區

十分鐘雨量：0.0 mm

一小時雨量：0.0 mm

三小時雨量：0.0 mm

六小時雨量：0.0 mm

12小時雨量：0.0 mm

24小時雨量：0.0 mm

本日雨量：0.0 mm

預測一小時雨量：nm

預測二小時雨量：nm

預測三小時雨量：nm

Google Crisis Response-Taiwan Disaster Prevention Map

<http://www.google.org/crisismap/taiwan>



臺灣防災地圖
發佈者：Google Inc.

圖例
-10 0 10 25 35 45 60 70

資料來源：中央氣象局 (CWB)
上次更新時間：下午4:05 (20 分鐘前)

☒ 災害示警
資料來源：中央氣象局, 水土保持局, 及水利署, 並透過 Google.org 的災害示警發佈

☒ 公路封閉
Highway closures
資料來源：公路總局 (DGH)
☐ 災害性封閉

☒ 預警性封閉
縮放至區域大小 · 下載 KML 檔
圖例
 道路預警性封閉

☐ 土石流警戒(含疏散避難路線圖&避難處所)

☒ 雲層
資料來源：Google 地圖

☒ 交通路況
資料來源：Google 地圖

☒ 土石流潛勢溪流
圖例
● 潛勢度高
● 潛勢度中
● 潛勢度低
● 持續觀察

Google Crisis Response
HOME RESPONSE EFFORTS FOR RESPONDERS FAC

Making critical information more accessible in times of disaster
When disaster strikes, people turn to the internet for information. We help ensure the right information is there in these times of need by building tools to collect and share emergency information, and by supporting first responders in using technology to help improve and save lives.
Photo courtesy of Bill & Melinda Gates Foundation*

Response Efforts Tools for Responders Work with Us



Public Warning System (PWS) for Natural Disasters

PWS utilizes cell broadcast technology, which can simultaneously send more than 100,000 messages in targeted regions within seconds (2,000 msg / min for telecoms)

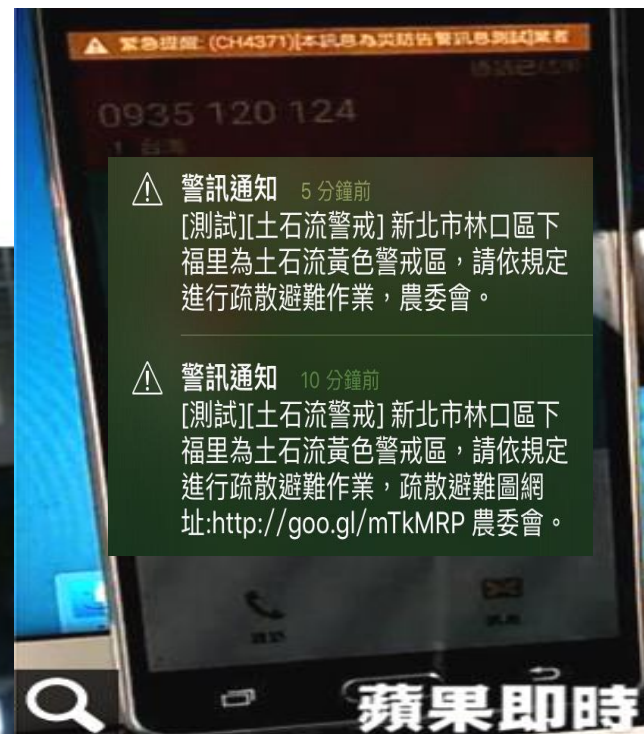
國內4G防災示警廣播系統完成，幾秒內可向上百萬手機發出災防警訊

災防告警細胞廣播訊息系統已建置完成，依NCC規劃5家4G業者預定4月起正式啟用，屆時若有天災發生，中央防災救援單位可透過4G業者即時向災害區域內上百萬民眾發送示警訊息。

文/ 蘇文彬 | 2016-01-04 發表

f 讚 2.4 萬 按讚加入iThome粉絲團 f 讚 分享 9

G+ 10





3. Mechanism of Comprehensive Self Prevention and Protection

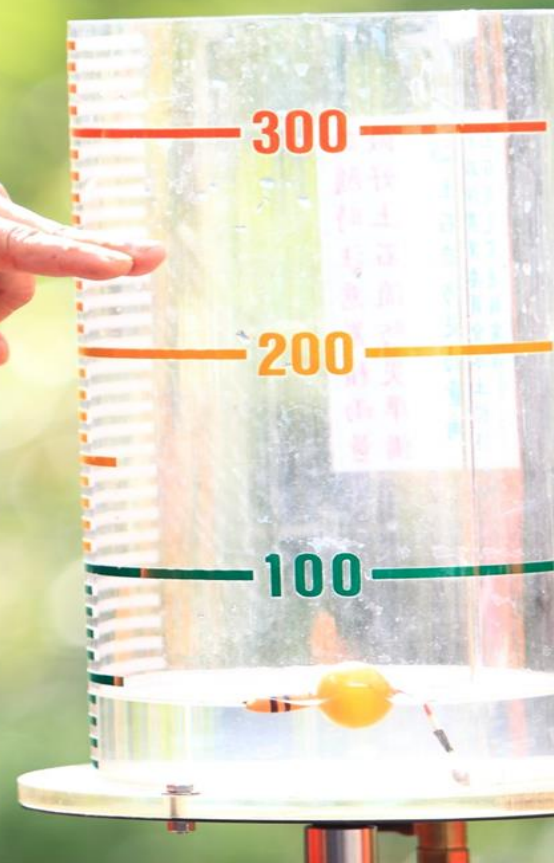
***Debris Flow Volunteer Specialist
Self-protecting Community***



2780

Debris Flow Volunteer Specialists

Coverage: 99%





Establish Self-protecting Community (550)

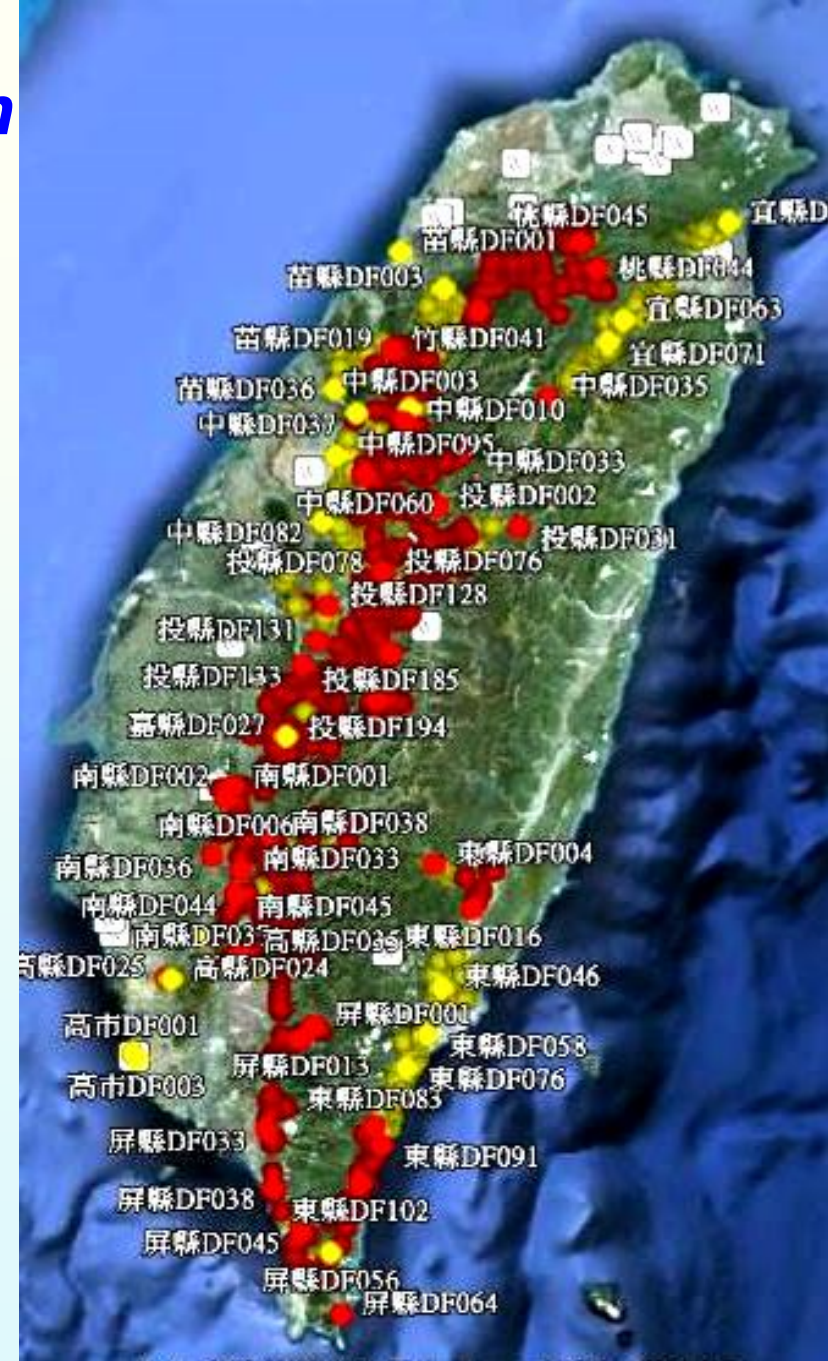
Encourage residents to join the working groups of debris flow disaster prevention project (warning, evacuation, shelter divisions)

Debris Flow Warning and Evacuation

◆ During the typhoon Morakot period, the SWCB had issued **21 debris flow warnings** to the public and local governments based on the real-time weather information from CWB.

| Debris flow warning | Warning ravines | County (City) | Town | Village |
|---------------------|-----------------|---------------|------|---------|
| Red alarm | 519 | 12 | 61 | 230 |
| Yellow alarm | 338 | 14 | 58 | 163 |

9,100 people were evacuated by local governments according to the warning. Among them, **1,046** people escaped from the possible casualties.



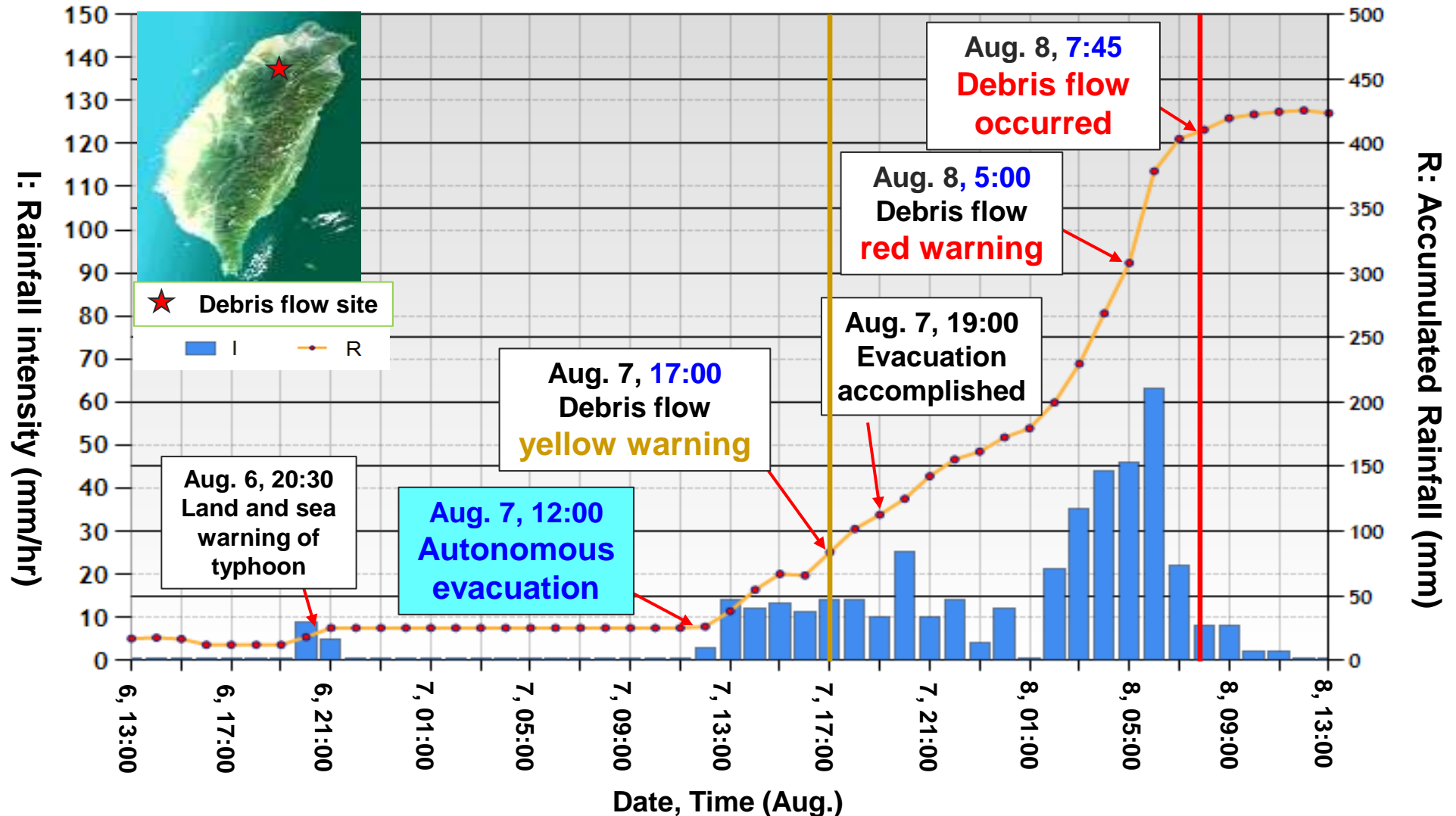
Debris flows in Heliu tribe, Taoyuan City during typhoon Soudelor on Aug. 8, 2015



15 houses were buried by debris flows
47 residents were evacuated beforehand



Timeline of Debris Flow Event



Key factors of successful evacuation

Village head Mr. Wang is debris flow volunteer specialist
Heliu is one of the self-protecting (resilient) community



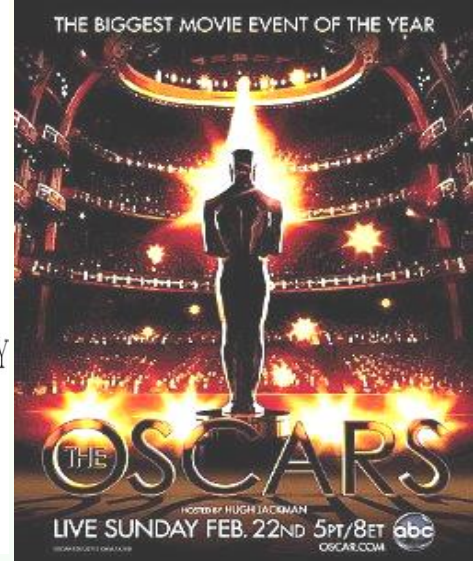


8th Government Service Quality Award in 2016

Comprehensive Self Prevention and Protection of Debris Flow Disasters



政府服務品質獎



The slit dam was destroyed by debris flows during typhoon Morakot in 2009

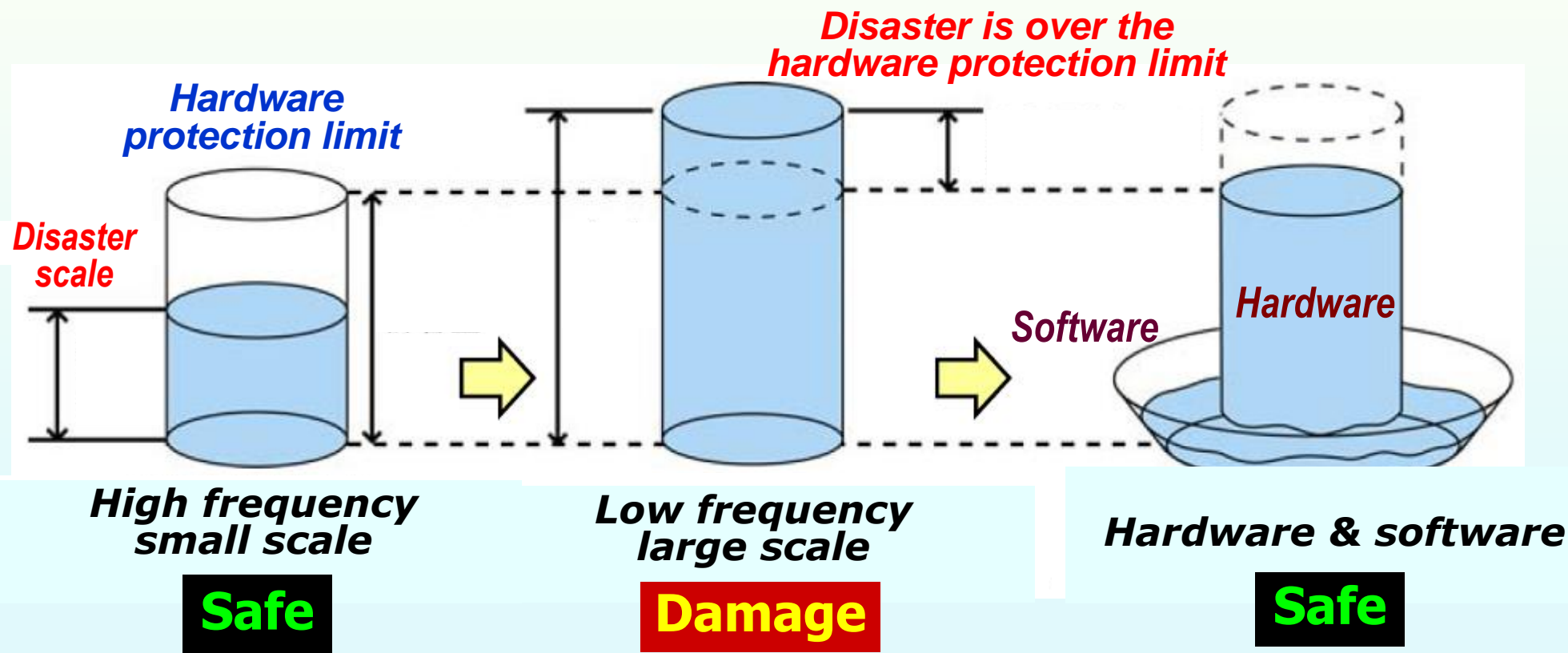


Reconstruction of the steel pipe permeable dam



Integration of Software and Hardware

- Under climate change impact, strategy of disaster precaution should be considered from hardware to software.
- Non-engineering measures should combine with mitigation works.





Natural Disaster Management

—T.H.I.N.K—

- ❖ ***Technology*** : Research, development and practice.
- ❖ ***Human management*** : Improve residents' awareness of precaution against disaster.
- ❖ ***Investigation*** : hazard map and event database.
- ❖ ***Notice*** : Early warning system and evacuation plan.
- ❖ ***Knowledge*** : Information for decision- making.



***Thank You for
Your Attention***

***Hsiao-Yuan(Samuel) Yin
sammya@mail.swcb.gov.tw***

***Soil and Water Conservation Bureau
Always Working with You***