



The 2019 International Training Workshop for Natural Disaster Reduction

Disaster Big Data Analysis and Application

Application of Big Data for Debris Flow Disaster Mitigation

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Soil and Water Conservation Bureau, Council of Agriculture***

May 1, 2019

Tropical cyclone frequency

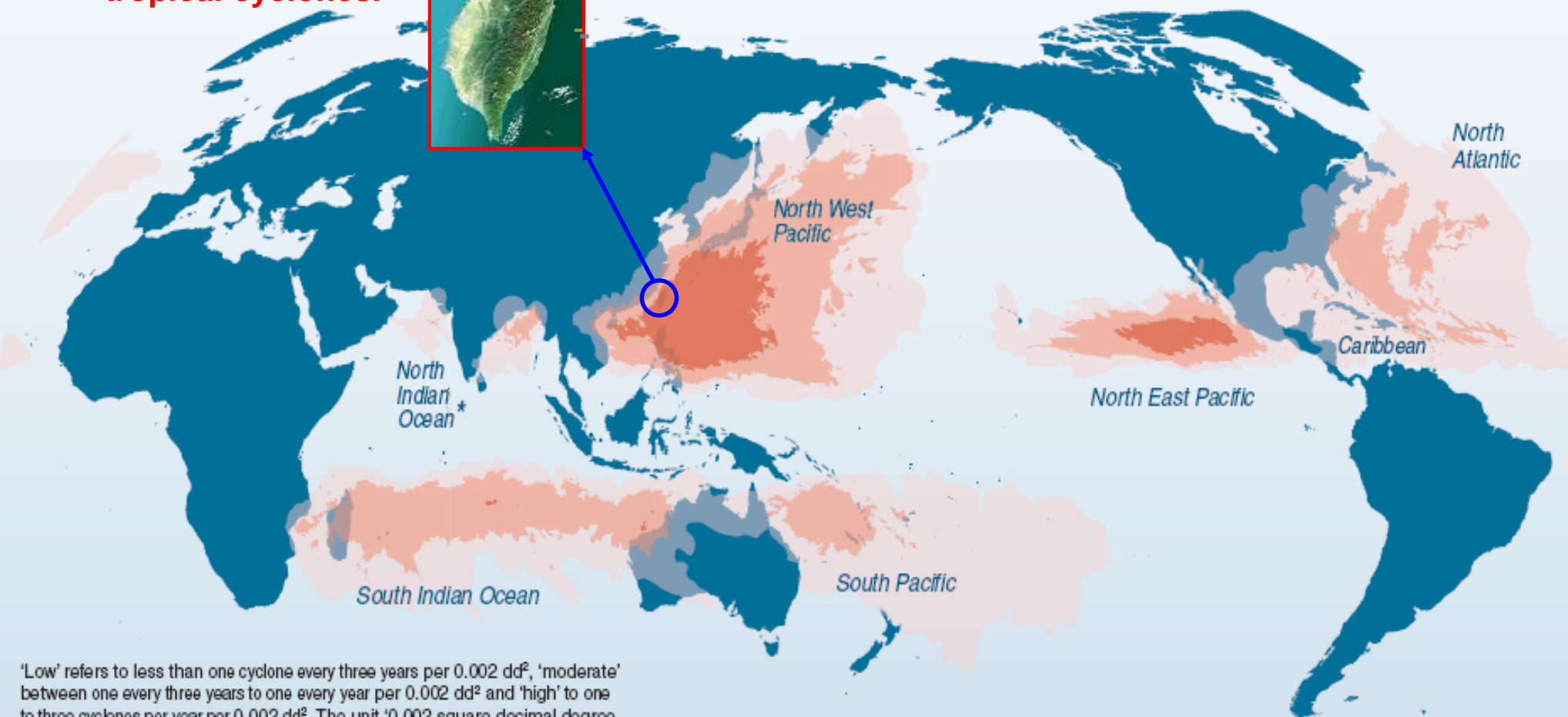
Taiwan

Taiwan is prone to tropical cyclones.



Average number of cyclones:
(1980-2000)

low moderate high



'Low' refers to less than one cyclone every three years per 0.002 dd², 'moderate' between one every three years to one every year per 0.002 dd² and 'high' to one to three cyclones per year per 0.002 dd². The unit '0.002 square decimal degree (dd²)' is equivalent to 25 km² on the equator, diminishing as latitude gets higher.

* average based on eight years only.

Sources: PREVIEW Global Cyclone Asymmetric Windspeed Profile, UNEP/GRID-Europe.

Historic Typhoon routes near Taiwan



集集大地震

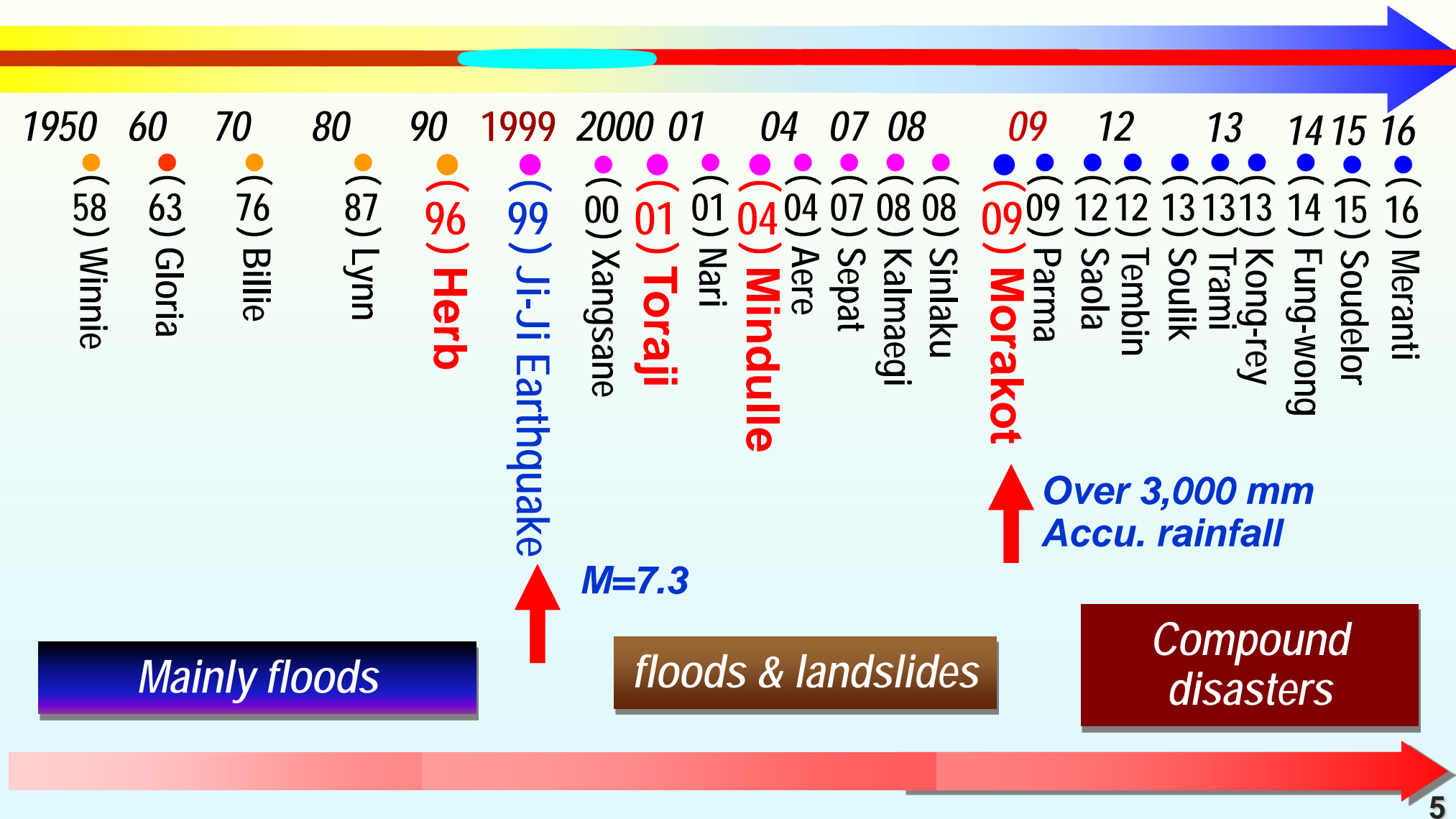
Sep. 21, 1999, Magnitude 7.3

(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



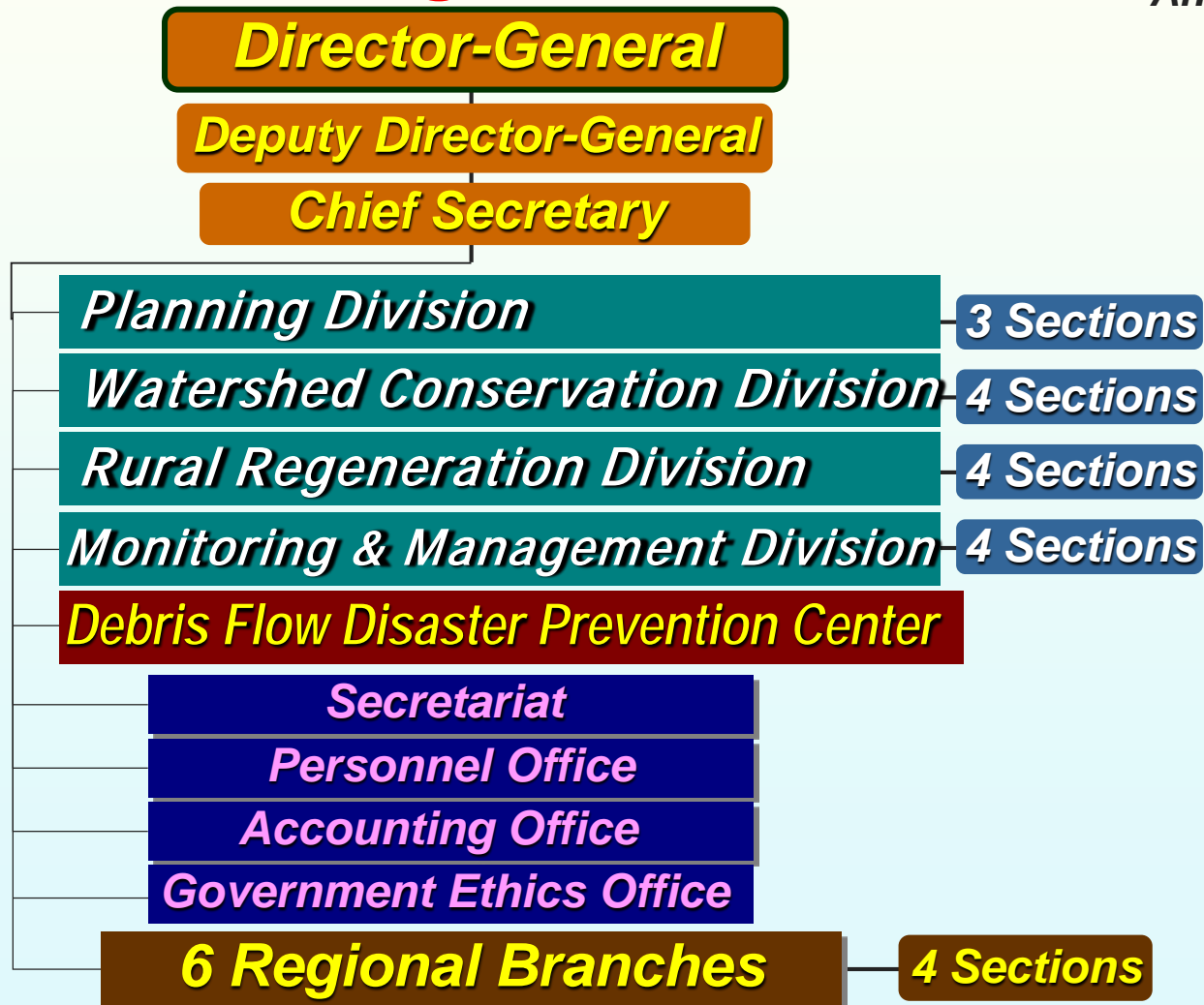
2004-Mindulle





Council of Agriculture
Soil & Water Conservation Bureau
Organization Chart

Total personnel : 540
Annual Budget : 380 million USD



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

**Source area
Landslides**

**Transportation part
Channel erosion**

**Deposition(fan) zone
Affected area**



1,725
Creeks

46,676
People

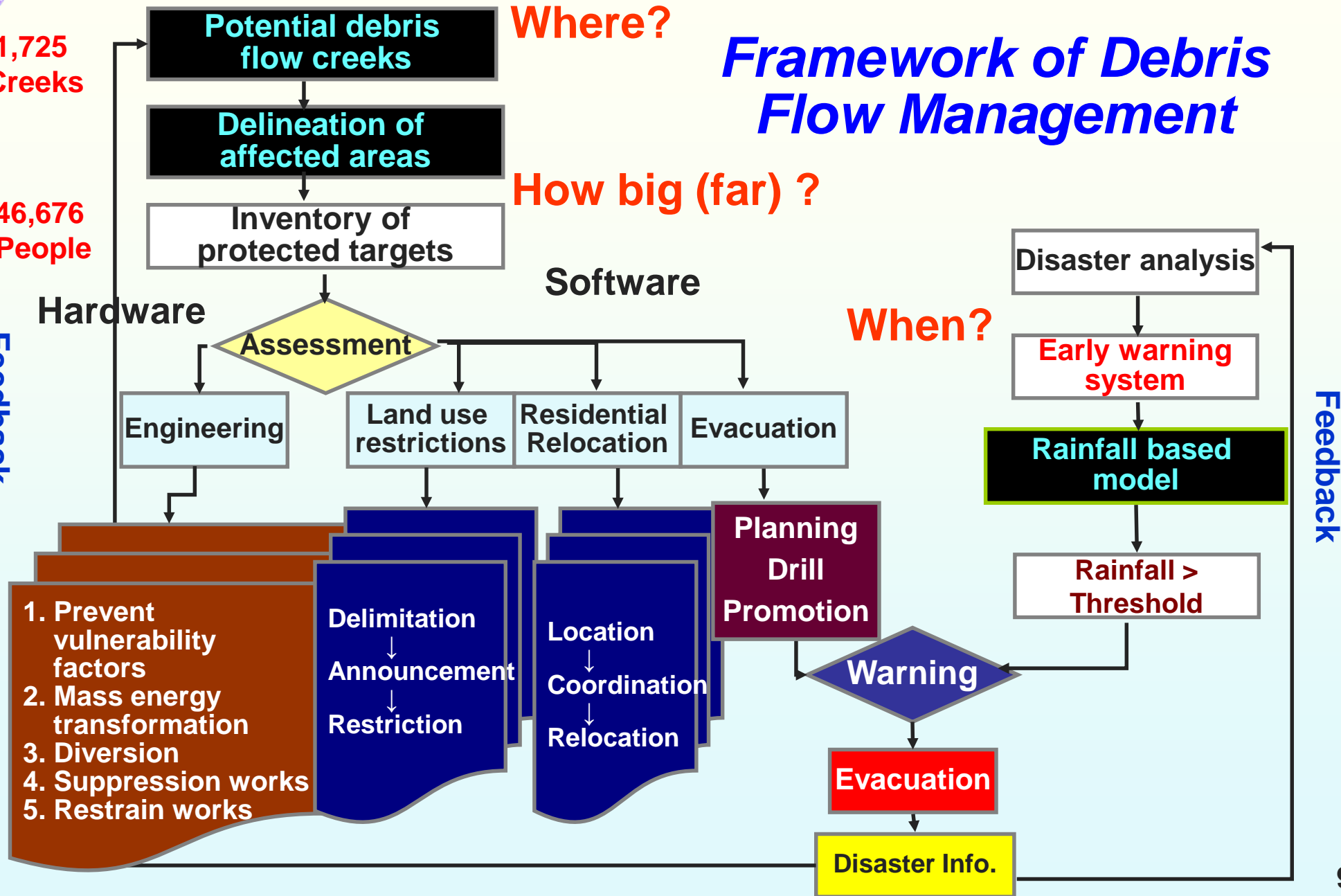
Feedback

Where?

Framework of Debris Flow Management

How big (far) ?

When?



Debris-flow Disaster Management Information (DDMI) System

Preparedness



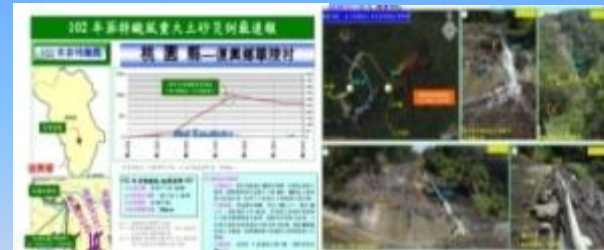
Potential debris flow creeks
Evacuation plans
Knowledge and education

Emergency response



Weather information
Early warning and monitoring
<http://fema.swcb.gov.tw>

Post-disaster survey



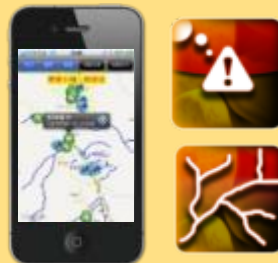
Events investigation
Remote sensing methods

Internal system

External website



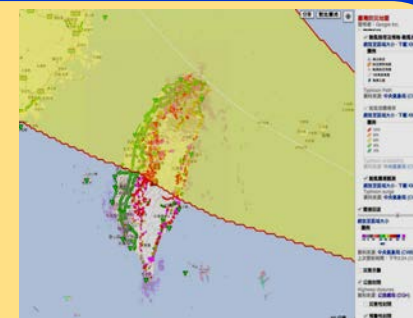
<http://246.swcb.gov.tw>



APP

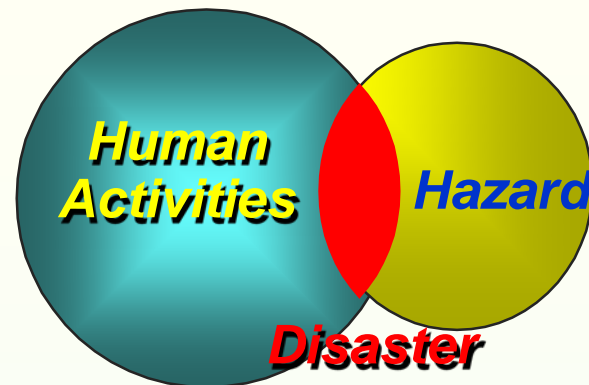


Facebook



Google earth

Investigation of 1,725 Potential Debris Flow Creeks



Risk Degree = Occurrence degree X Degree of hazards on protected targets

Occurrence Degree

- Watershed area, landslide ratio, drainage slope, sedimentation amount, geological structure, vegetation, historical events

Protected Targets

- Downstream fan areas

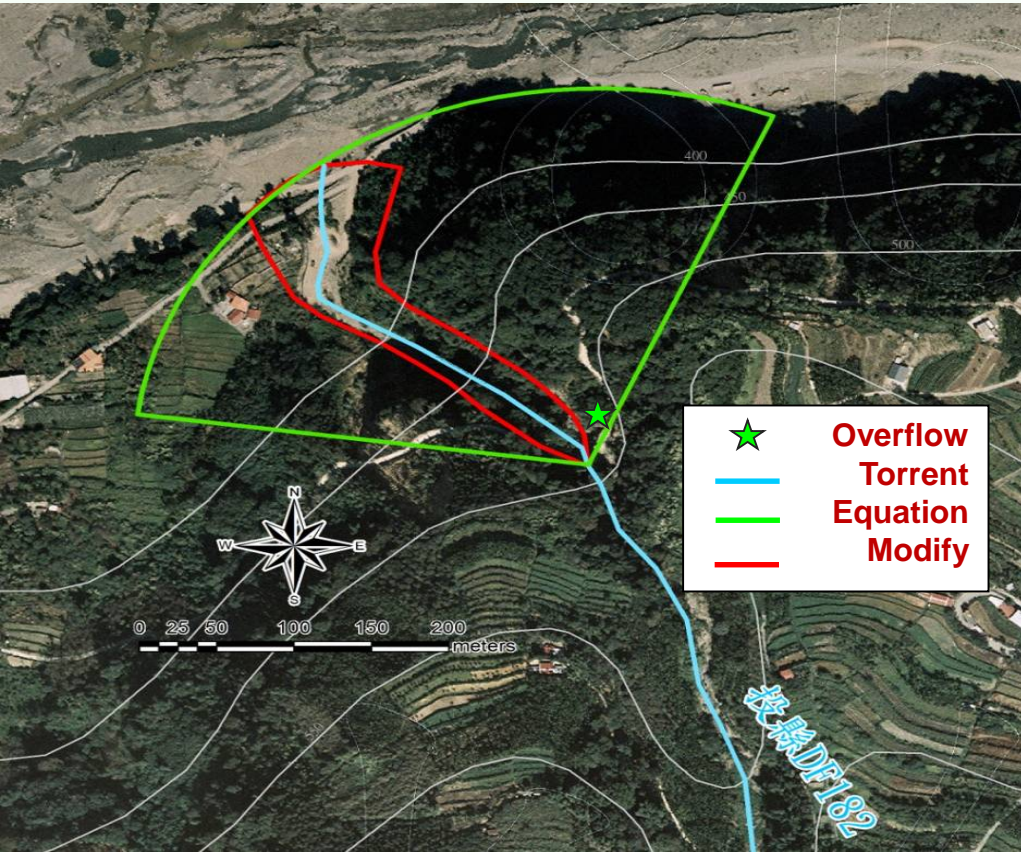
- People, living houses, public buildings, roads, bridges, other infrastructures

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



Affected area zoning

- The apex of fan area was selected at **valley exit point** with **105 degree fan area**, the **run-out-distance** (radius of the fan) was calculated by **Hiroshi equation** as well as **FLO-2D** simulation.
- Eliminate the un-passable areas, for example if banks were **10~12m** higher than channel.



Hiroshi equation

$$\text{Log}(L) = 0.42 \times \text{Log}(V \times \tan \theta_d) + 0.935$$

$$V = 70,992 A^{0.61} \quad (\text{Hsieh, 2000})$$

V = estimated debris volume (m^3)

L = run out distance (m)

A = watershed area (km^2)

θ_d = Slope of torrent

Debris-flow Disaster Management Information(DDMI) System

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

土石流防災資訊網

防災監測

土石流資訊

防災應用

防災成果

下載與服務

重要公告

2019/04/22 因應108年0418花蓮地震，緊急調降花蓮縣（秀林鄉）等1縣1鄉鎮共25條土石流潛勢溪流之
2018/10/24 107年土石流潛勢溪流說明會開始報名，詳情請點連結至報名網頁

+ 更多公告

Potential debris flow creek inquiry

土石流資訊便利搜

1.選擇縣市

土石流基準值

分布

土石流潛勢溪流共

1725條

分布159鄉鎮、689村里

2.選擇鄉鎮

3.選擇村里

列表

Evacuation map

縣市政府疏散避難圖

連結

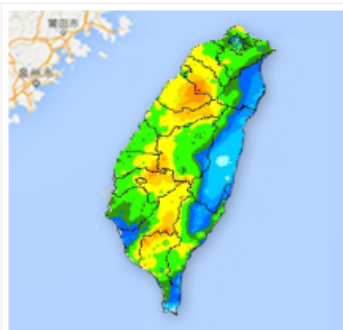
(連結至縣市政府網頁)

簡表

下載

Warning criteria

掌握土石流資訊



即時雨量

Real-time rainfall



觀測站展示平台

Debris flow monitoring

Debris flow knowledge



土石流介紹



防災任務

防災線上課程



107年度防災社區...

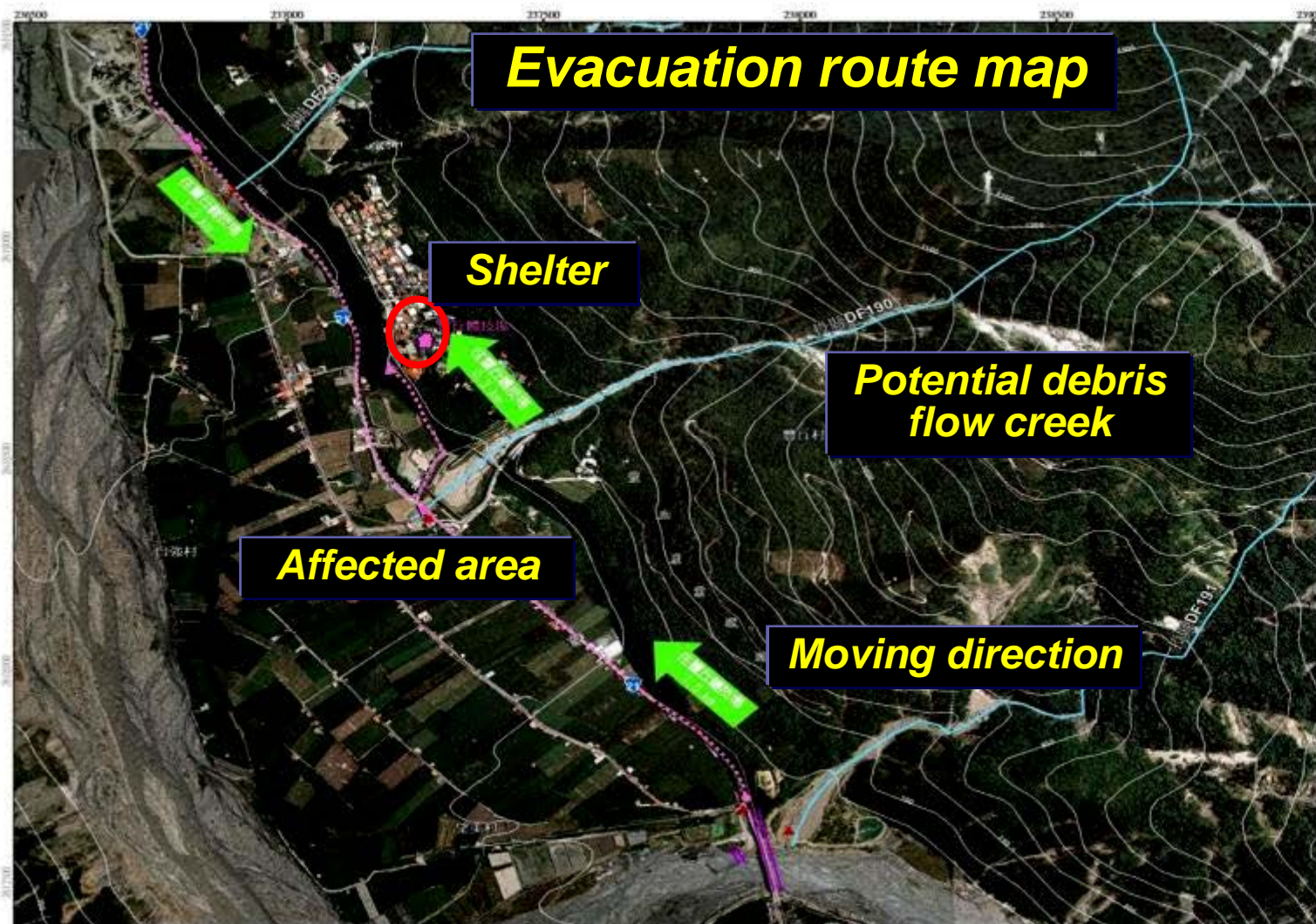
防災社區輔導團推動經驗分享

臺灣大學氣候天氣災害研究中心 柯凱元
副組長

+ 更多課程

Debris-flow Disaster Management Information(DDMI) System

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



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
- 水土保持局土石流災害緊急應變小組
電話:0800-246246
- 水土保持局南投分局緊急應變小組
電話:049-2221847

緊急聯絡人電話

- 村長:金美智 電話:049-2791552
手機:0935-678249

避難處所

- 豐丘體技場(可容納150人)
地址:信義鄉豐丘村高平巷8號
電話:049-2791583

直升機起降點

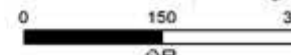
- 豐丘國小操場
地址:信義鄉豐丘村高平巷77號
電話:049-2791723

警消醫療單位

- 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:竹山鎮英山路二段75號
電話:049-2624266
- 豐丘派出所
地址:信義鄉豐丘村高平巷8號
電話:049-2791583
- 信義消防分隊
地址:信義鄉明德街50號
電話:049-2791760

Shelter information

尼爾森颱風、民國85年賀伯



南投縣信義鄉豐丘村土石流疏散避難圖(1/2)

• 方格線黑色數字為TWD97坐標
• 方格線灰色數字為TWD67坐標

行政院農業委員會水土保持局
資料更新日期102年3月
版圖繪圖日期93年08月

On-line Submission - Inventory of Protected Targets

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

Designed for local government


**行政院
農業委員會 水土保持局**


線上使用人數： ■ ■ ■

使用單位： 水土保持局土石流防災中心

46,676 People

功能模組 | **重點捷徑** | **A 保全清冊** | **A1 其他保全清冊** | **B 影響範圍** | **C 避難處所** | **D 重機械待命點** | **E 災情通訊錄** | **T 規劃演練** | **M 圖形功能** | **S 統計資料** | **X 其他功能** | **P 網站地圖** | **H 回到首頁** | **O 登出系統**

保全對象統計表 (PR20L)

A-1

新增資料

匯出結果 (Excel)

持續觀察：

原住民地區： [不設定]

不顯示

Disadvantaged minority

共 90 筆資料

第 3 頁 / 共 9 頁；跳至第 頁

執行

上一頁 **下一頁**

溪流編號	警戒	縣市	鄉鎮	村里	溢流點	保全對象地址	姓名	性別	生日(年/月/日)	實際居住	弱勢族群	家庭電話	行動電話	避難處所	緊急連絡人	修改
投縣DF190	—	南投縣	信義鄉	豐丘村	CD01	敦福路102號	胡木火	男	12/01/15	是	否	無		豐丘國小	049-2791484-0935-678249	
投縣DF190	—	南投縣	信義鄉	豐丘村	CD01	敦福路102號	胡現	女	80/06/27	是	身心障礙	無		豐丘國小	全美智 049-2791484-0935-678249	
投縣DF190	—	南投縣	信義鄉	豐丘村	CD01	敦福路103號	石天賜	男	29/11/24	否	身心障礙			豐丘國小	全美智 049-2791484-0935-678249	
投縣DF190	—	南投縣	信義鄉	豐丘村	CD01	敦福路103號	石蕭星	女	30/03/20	否	身心障礙			豐丘國小	全美智 049-2791484-0935-678249	
投縣DF190	—	南投縣	信義鄉	豐丘村	CD01	敦福路103號	石錫鈴	男	54/03/20	否	身心障礙		0915-068033	豐丘國小	全美智 049-2791484-0935-678249	

影響範圍連絡人清冊 A-3

防災專員清冊 A-4

校核保全清冊 A-6

有疑異保全清冊 A-7

聯絡電話比對成果 A-8

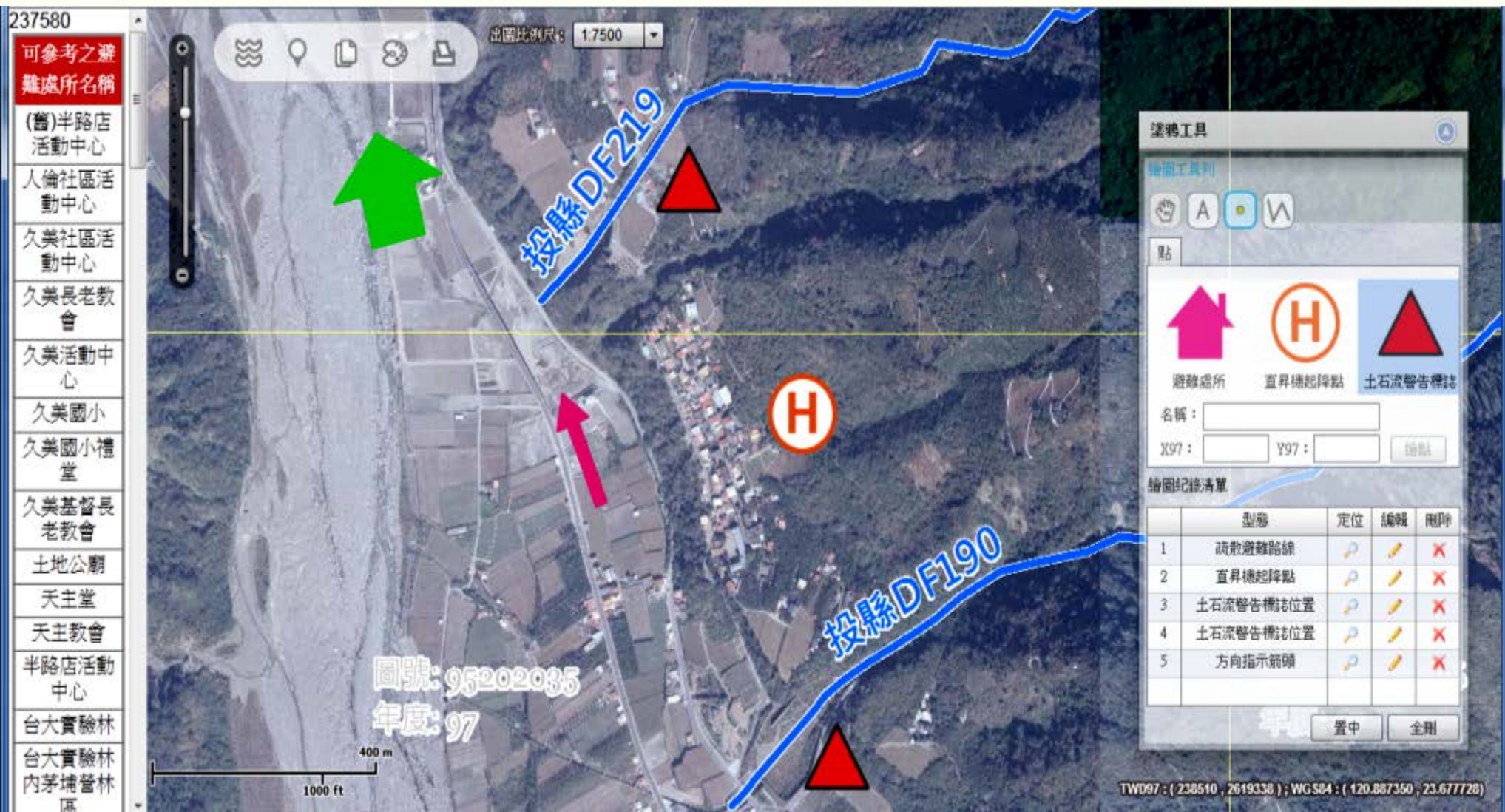
回首頁

登出

On-line Modification of Evacuation Route Map

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

Designed for local government



237580

可參考之避難處所名稱

- (舊)半路店活動中心
- 人倫社區活動中心
- 久美社區活動中心
- 久美長老教會
- 久美活動中心
- 久美國小
- 久美國小禮堂
- 久美基督長老教會
- 土地公廟
- 天主堂
- 天主教會
- 半路店活動中心
- 台大實驗林
- 台大實驗林內茅埔營林區

出圖比例尺: 1:7500

投縣DF219

投縣DF190

圖號: 95202035
年度: 97

400 m
1000 ft

塗鴉工具

繪圖工具列

點

避難處所 (House icon)

直昇機起降點 (H icon)

土石流警告標誌 (Triangle icon)

名稱:

X97: Y97:

繪圖紀錄清單

	型態	定位	編輯	刪除
1	疏散避難路線			
2	直昇機起降點			
3	土石流警告標誌位置			
4	土石流警告標誌位置			
5	方向指示箭頭			

置中 全圖

TWD97: (238510 , 2619338); WGS84: (120.887350 , 23.677728)

Localized Rainfall-based Debris-flow Warning Model

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

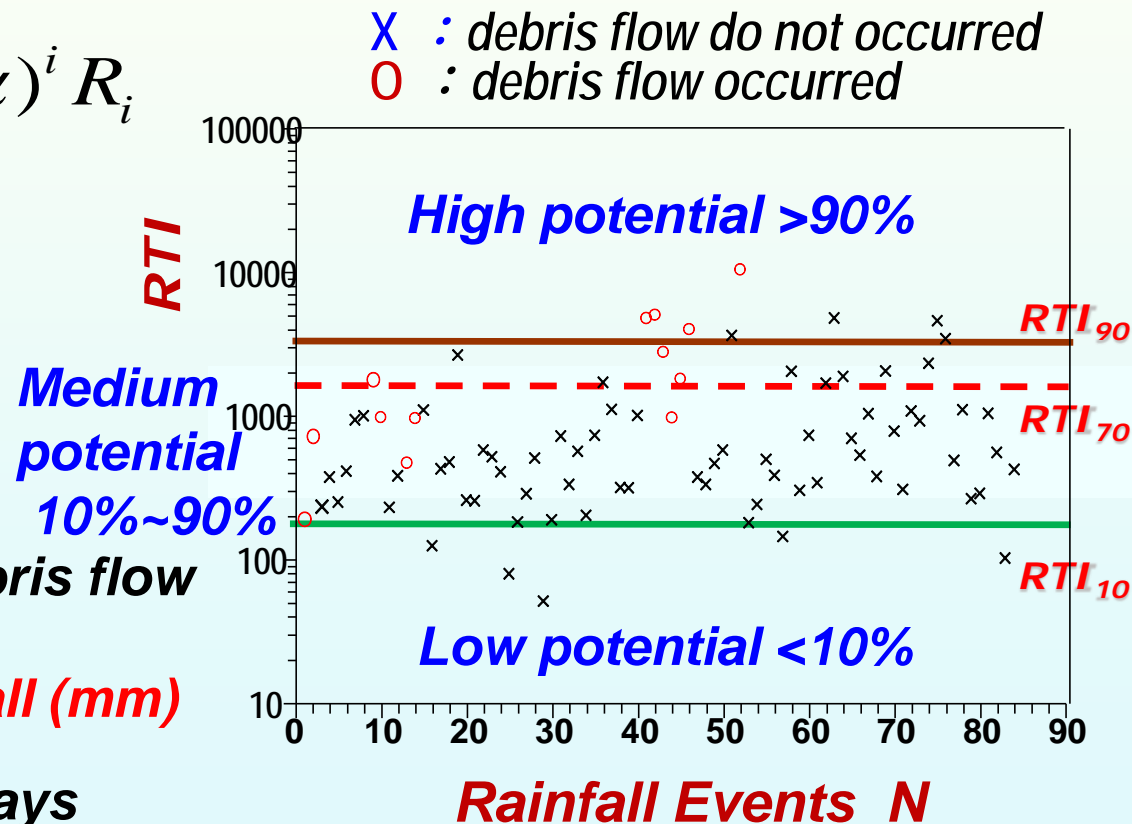
$$RTI = I \times R_t \quad R_t = \sum_{i=0}^7 (\alpha)^i R_i$$

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





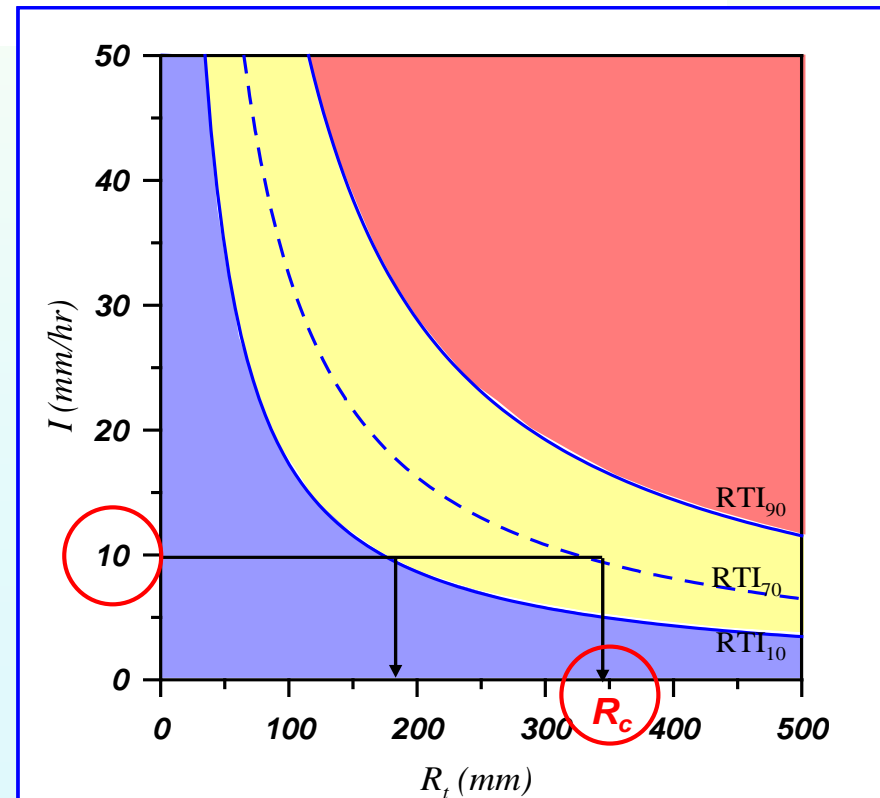
Simplified RTI model

The **RTI** value involving **I** and **R** is too complicated for the residents living in mountainous areas to understand.

However, the simplified **Critical Accumulated Rainfall (R_c)** is much easier for the public understanding and application.

R_c is estimated from the critical RTI-value with the consideration of **10 mm/hr rainfall intensity**.

With **50mm** as an interval, the Critical Accumulated Rainfall **R_c** can be classified into 9 categories in different regions. They are 200, 250, 300, 350, 400, 450, 500, 550, or 600 mm.



Warning Criteria Table

Village and (N) : the numbers of debris flow creeks in the village

Rainfall station 2

Rainfall station 1

104年土石流警戒基準值明細表 104.01修訂

縣市	鄉鎮	警戒區範圍		土石流警戒基準值 (mm)	參考雨量站	
		警戒區座落村里 (土石流潛勢溪流總數)	土石流潛勢溪流數(條)		代表站1	代表站2
	蘇澳鎮	永春里(2)	2	500	蘇澳	東澳嶺
		永樂里(7)	7		東澳嶺	蘇澳
		朝陽里(4)	4		南澳	烏石鼻
		南建里(1)、長安里(1)、蘇北里(1)、聖湖里(4)	7		蘇澳	冬山

Township

Warning Criteria (mm)

Numbers of debris flow creeks in township



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

Mandatory
Evacuation

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

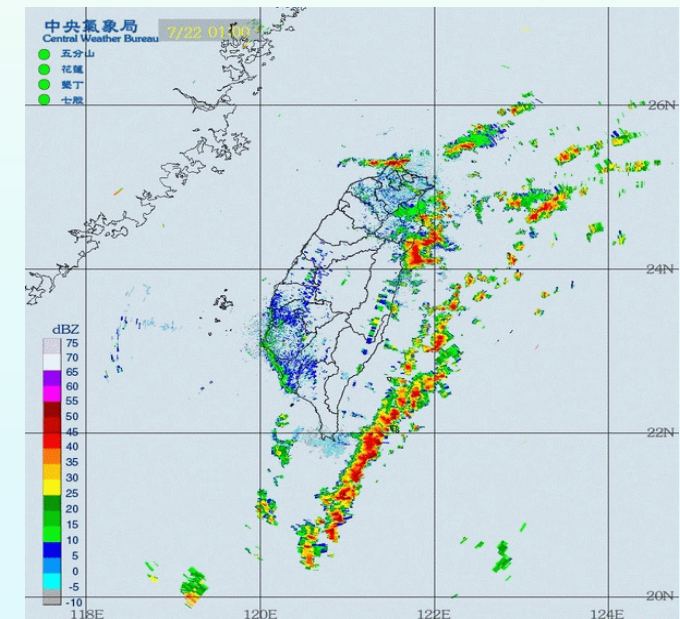
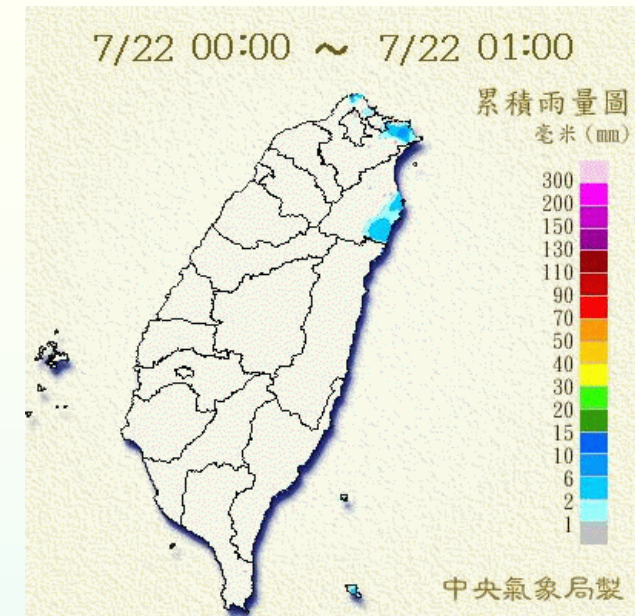


Debris Flow Emergency Operation Task Force of SWCB

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

- Web-based decision making system (FEMA)
- Real-time rainfall data over **507** 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





Difficulties of Rain Gauges

Proportion of rain gauges

- ◆ The number of **reference rain gauges** for debris flow warning is **507** (63% belongs to CWB).

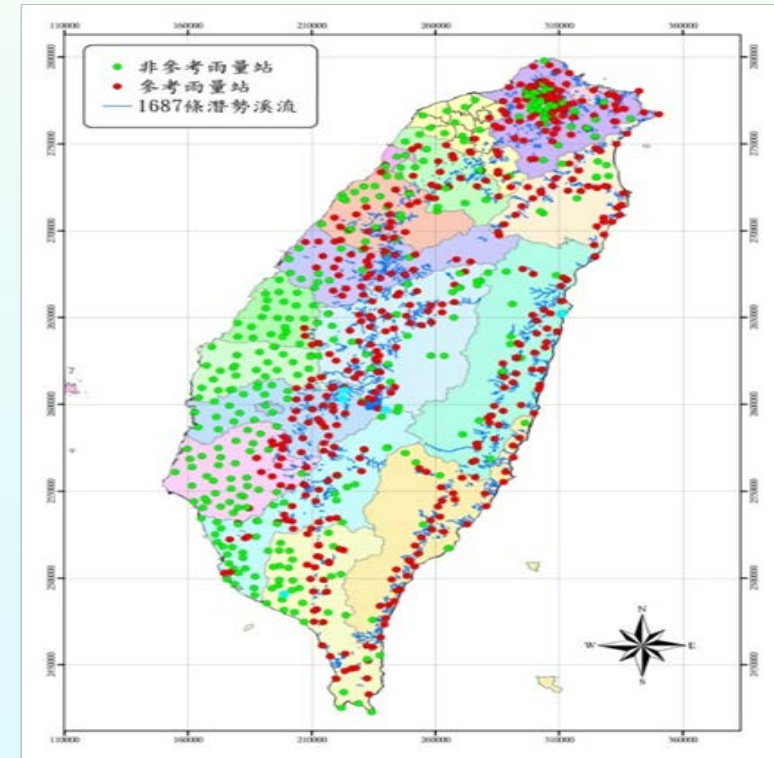


Disadvantages of rain gauges

- ◆ Low density in mountainous areas.
- ◆ High cost for maintenance.
- ◆ High cost to establish new station.
- ◆ Transmission problems during heavy rainfall.
- ◆ Point data. Spatial representative is limited.

Solutions

- ◆ To establish new rain gauges.
- ◆ **Apply the Radar system(QPESUMS)**

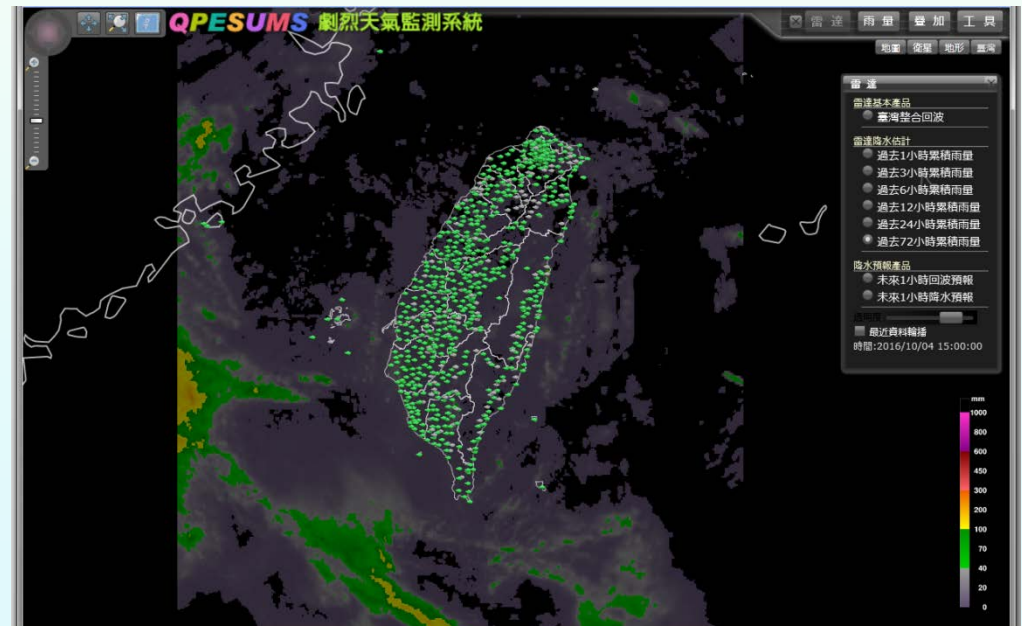
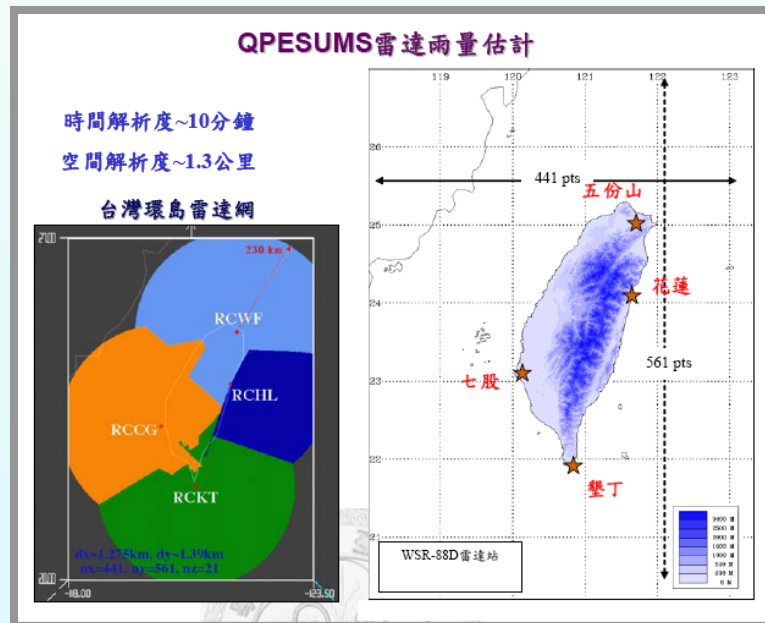




Radar-derived Rainfall (QPESUMS)

Precipitation estimation from radar has advantages **providing the complete spatial coverage including mountain areas**. Furthermore, the radar estimation has **better spatial resolutions** than traditional **rain gauges (point data)**.

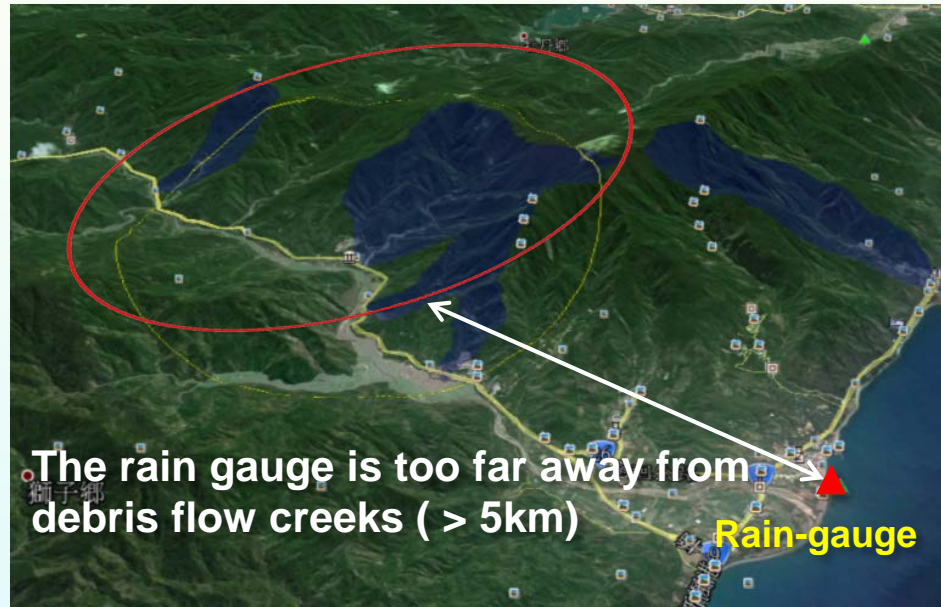
- ✓ Time resolution : 10 minutes Spatial resolution : 1.3km X 1.3km
- ✓ Rainfall prediction : 1 hr, 2 hr, 3 hr.....





Application of QPESUMS Grids

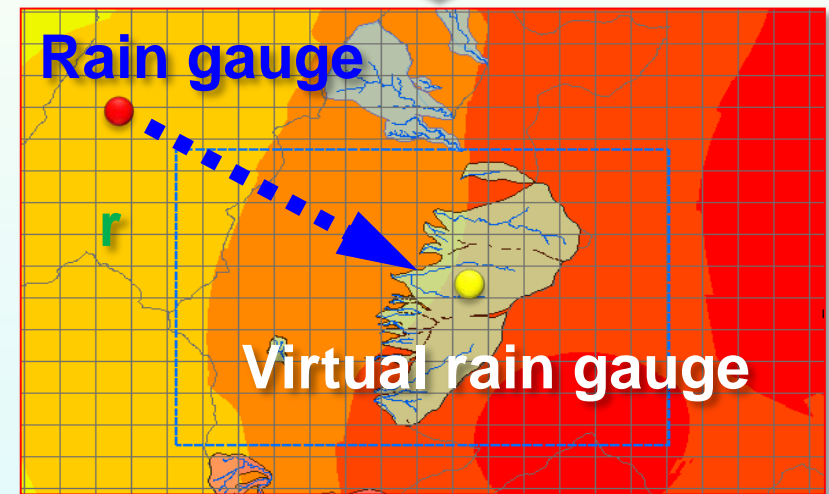
Shortage of reference rain gauge especially in mountain areas.



✓ It doesn't change the current operating procedure of debris flow warning (reference rain gauge).



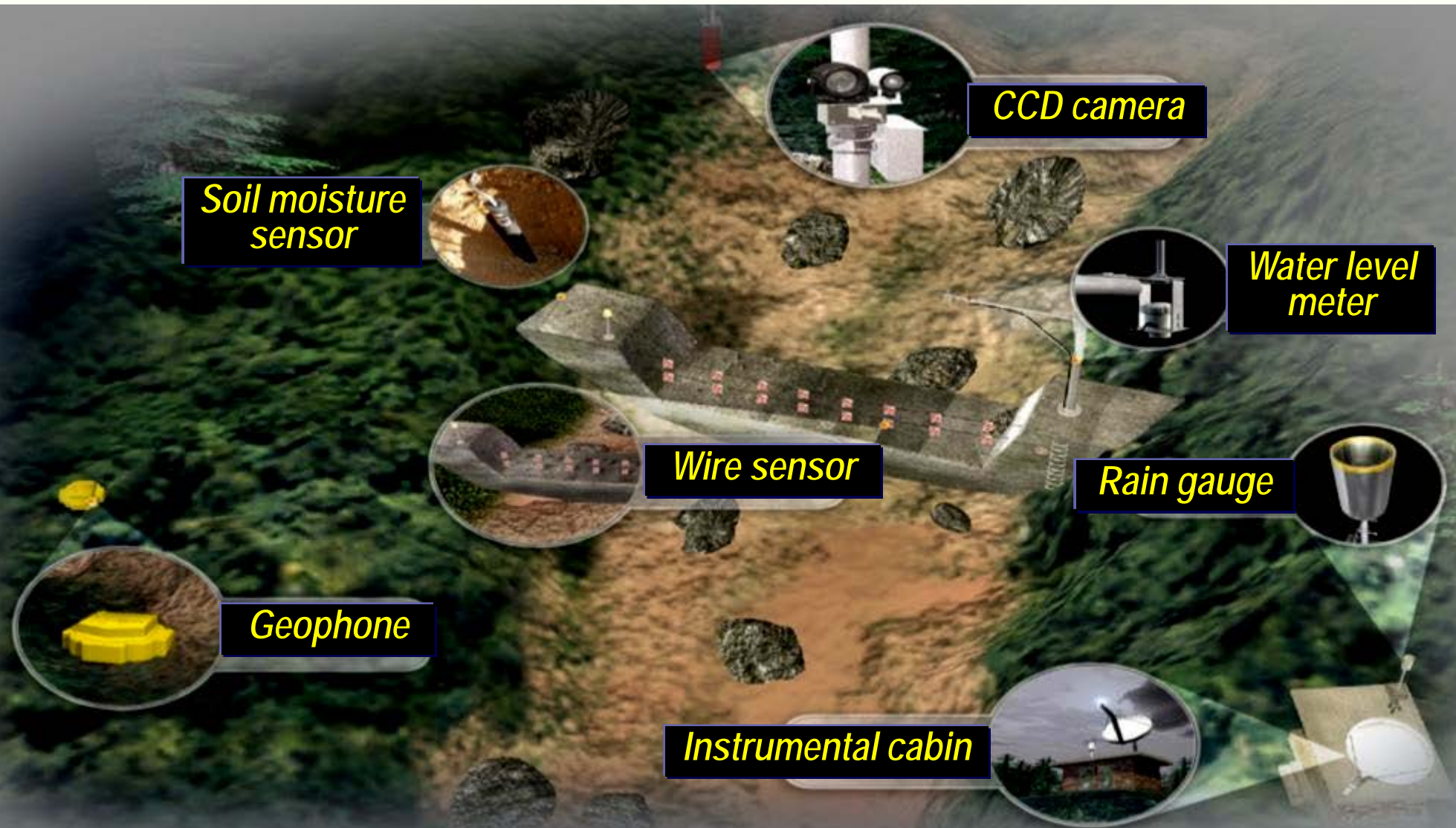
Assuming there is a **virtual rain gauge** within the **warning district** of potential debris flow torrent designed in advance.



Precipitation of virtual rain gauge (like reference rain gauge) is estimated from radar-derived rainfall (QPE)



On-site Debris Flow Monitoring



On-site Debris Flow Monitoring



**Display through
DDMI system and APPs**





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

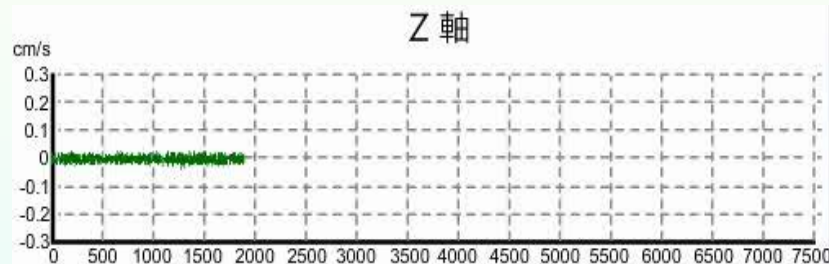
↓ Wires broke at 12:53:44

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

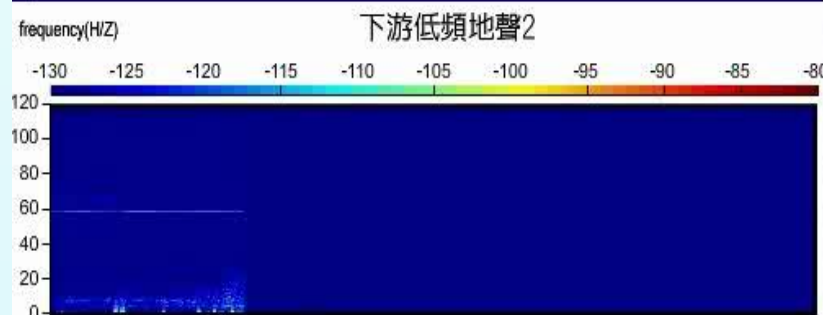
geophone



seismometer



spectrum



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

Origin of Debris Flow Disaster Resistant Community

Debris Flow Disaster in Songhe Tribe
Typhoon Mindulle on July 2, 2004

- 60 houses were buried
- 1 casualty

Delivery of simple rain gauge on May 24, 2004)



July 7, 2004



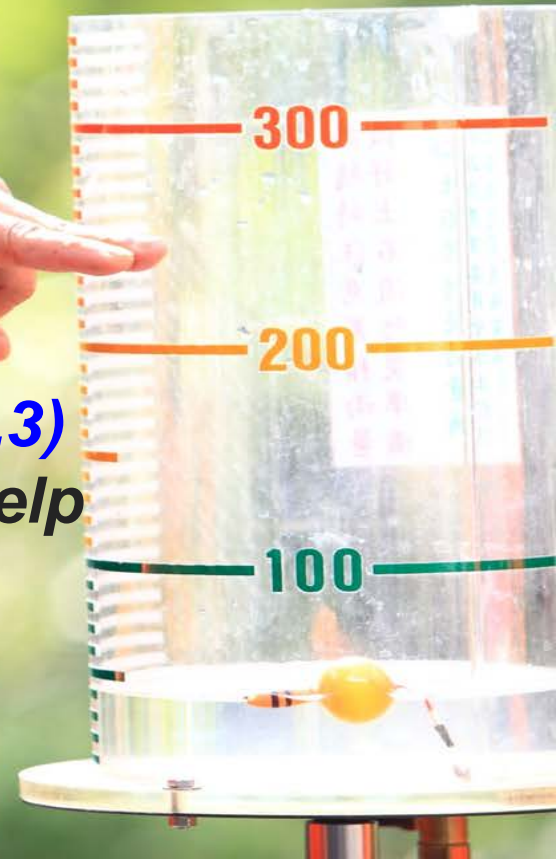
2780

Debris Flow Volunteer Specialists

Coverage: 99%

1995 Hanshin Earthquake(M=7.3)
Self help: Mutual help: Public help

7 : 2 : 1



VR application



Training Courses



Simple rain gauge

Crossroad- Yes No questions



4-Directions meeting





DIY Rain-gauge Using PET Bottle

材料 2公升裝寶特瓶空瓶、石膏（或水泥、蠟）、小刀或剪刀、15公分直尺

做法



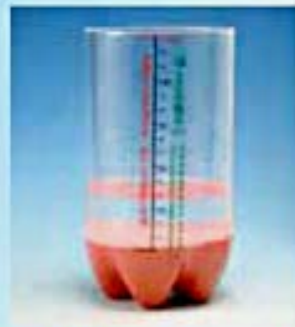
1 將寶特瓶上半部圓弧切除



2 在瓶身中間直段貼上直尺



3 將底部不規則部份(約6公分以下)充填石膏固定，以增加重量避免傾倒。



4 下雨時移至戶外，觀測累積雨量，當24小時內超過15公分，請儘早疏散。





Establish Disaster Resistant Community (550)

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



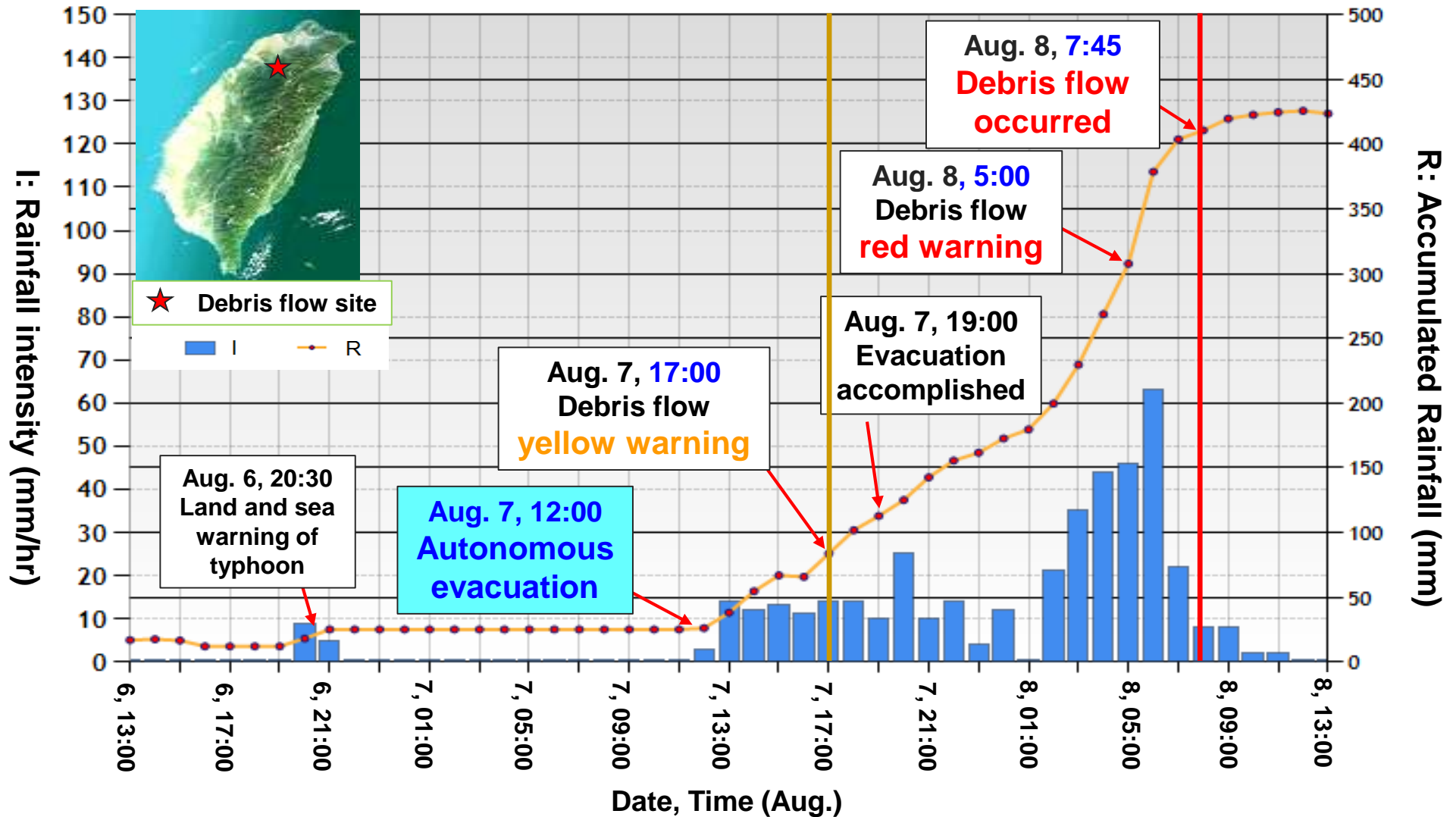
Debris flows in Heliu tribe, Taoyuan City during typhoon Soudelor on Aug. 8, 2015



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 disaster resistant(resilient) community



During typhoon Morakot in 2009, 9,100 people were evacuated. Among them, 1,046 people escaped from the possible casualties.

Free Apps for Debris Flow Prevention

Google map application

iOS
Android



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) including **earthquake, torrential rain, debris flow, traffic closure, reservoir discharge...**

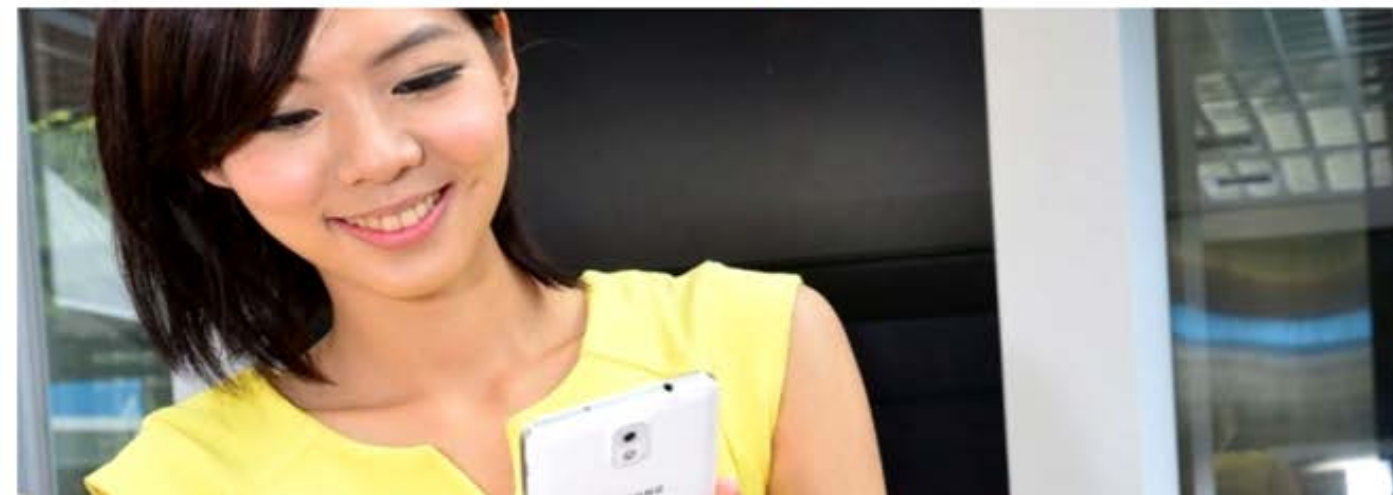
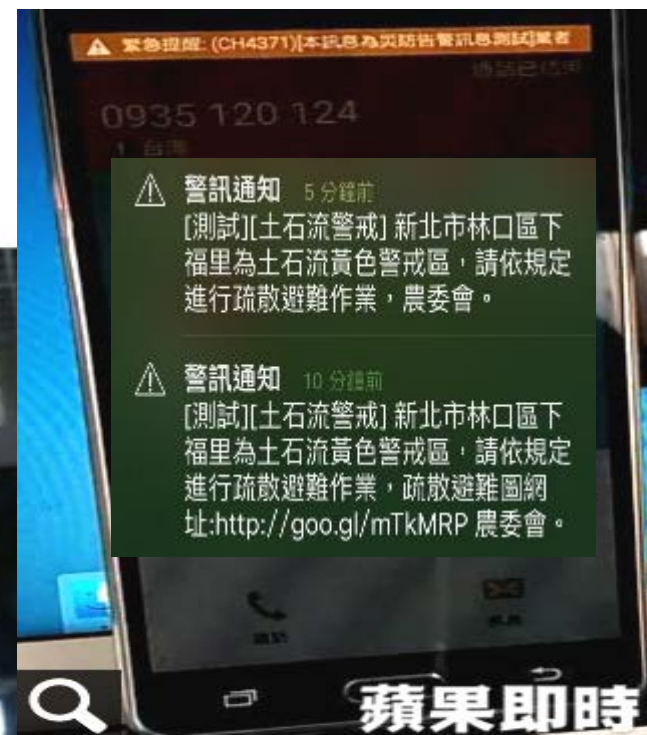
Making warning info. accessible to the public during emergency period

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

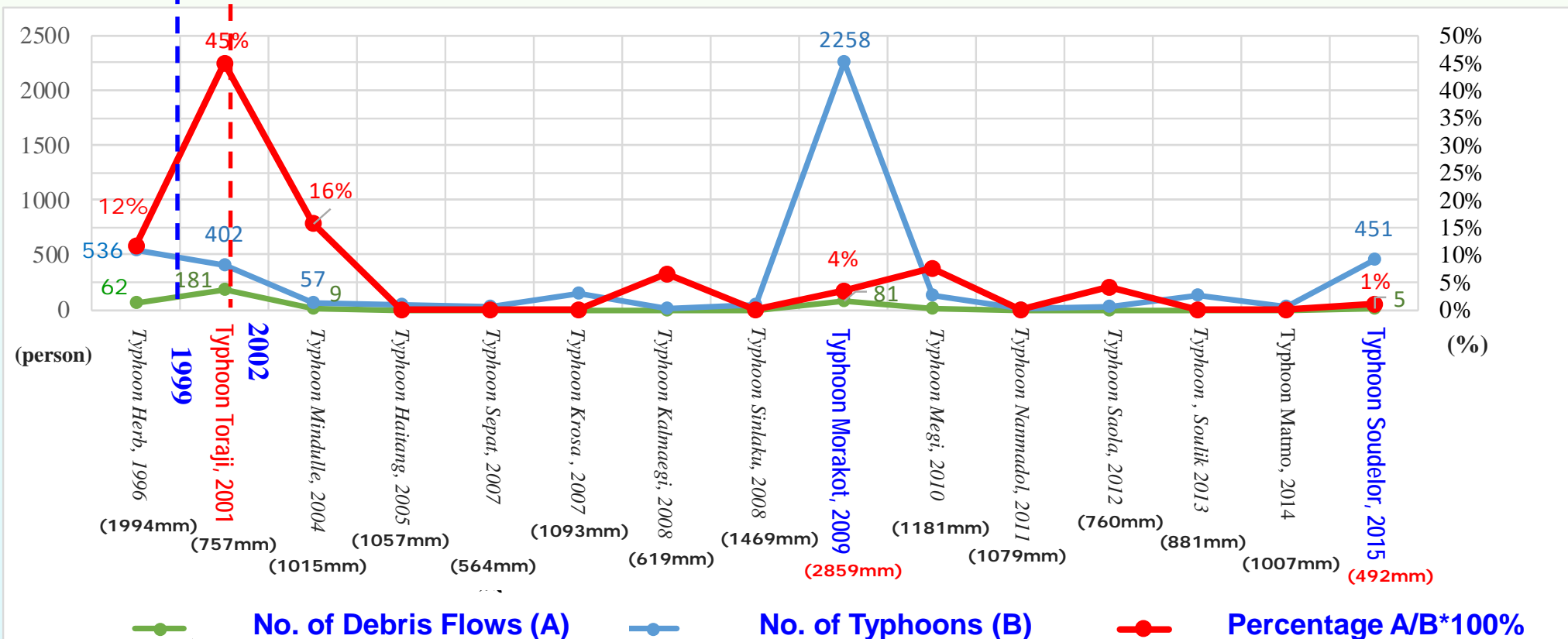
f 讚 2.4 萬 按讚加入iThome粉絲團 G+ 10 f 讚 分享



No. of Casualties and Wounded Debris Flows vs Typhoon

**M=7.3 Chi-Chi
earthquake**

Disaster prevention mechanism has been implemented since 2004.



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

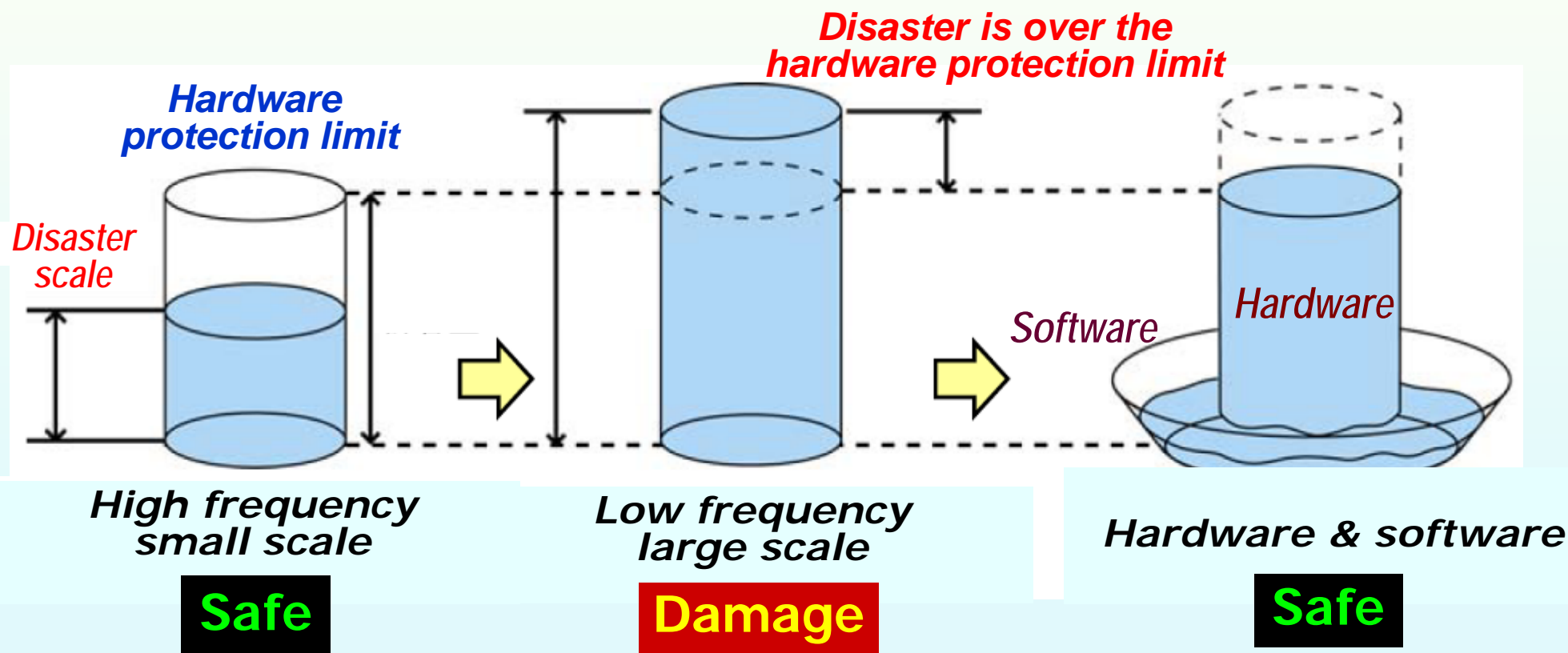


Reconstruction of the permeable dam



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 mapping and event database.
- ❖ ***Notice*** : Early warning system and evacuation plan.
- ❖ ***Knowledge*** : Information for decision- making and disaster mitigation.



2019 Geospatial World Excellence Awards

Intelligent disaster prevention and decision-making network for debris flow monitoring





***Thank You for
Your Attention***

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

Efficiency of Debris Flow Warning Model

Warning Accuracy (%)

$$= \frac{\text{NO. of warning township with debris flow events}}{\text{NO. of warning township}}$$

Warning Coverage (%)

$$= \frac{\text{NO. of debris flow events in warning areas}}{\text{NO. of debris flow events}}$$

*From the historic statistics, the warning accuracy of **typhoons** is higher than torrential rain because of the different rainfall patterns.*

Year	Accuracy (%)	Coverage (%)
2005	6.4	100
2006	9.1	100
2007	6.3	66.7
2008	9.1	100
2009	20.6	85.7
2010	11.5	81.8
2011	10.5	72.7
2012	7.2	92.3
2013	2.7	100
Average	9.3	89.0