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

Possible threats from slopeland disasters and countermeasures for disaster mitigation

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Outline

NCDR

www.ncdr.nat.gov.tw

1. **Rainfall characteristics caused disasters in mountain area**

2. **Category of disasters in mountain area**

3. **Summary problems due to disaster**

4. **Countermeasures for Disaster Response during typhoon Morakot**
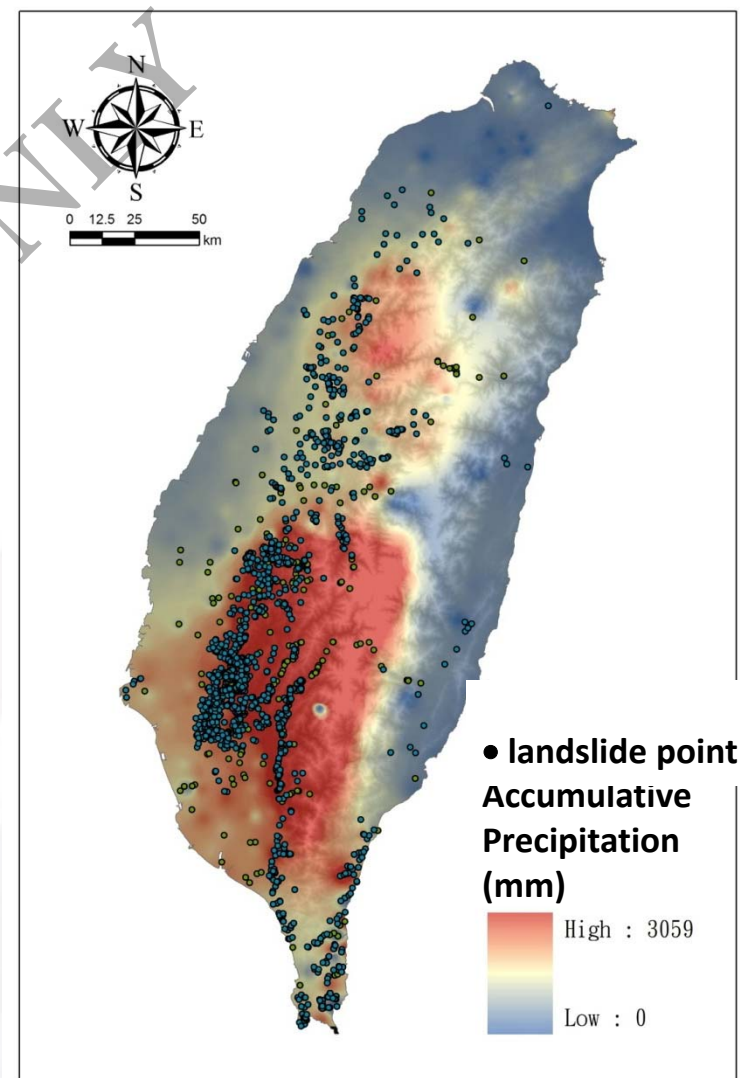
5. **Conclusions**

Rainfall characteristics of Typhoon Morakot

Spatial Distribution of landslide locations

1. **Long duration, high intensity , high accumulative rainfall depth**

2. **About 9% area of Taiwan was covered under the heavy rainfall (≧ 2000mm)**

3. **Exceeded the accumulative precipitation of the stability of slope lands.**

4. **Over 1600 landslide spots in Taiwan**

5. **Main affected areas included, Zhuoshu ,Tsengwen, KaoPing watershld by landslide.**

6. **Landslides located within the range of precipitation > 1,000mm**

7. **Precipitation > 2,000mm: the most serious area**

● landslide point
Accumulative
Precipitation
(mm)

High : 3059

Low : 0

0 12.5 25   50
km

2. Category of disasters in mountain area

2. Disasters in the mountain

1. **Landslides**
2. **Debris flow**
3. **Driftwood**
4. **Landslide dams**

Source: NCKU

2.1 Landslide Area

Area of landslide increased

39,492 hectares

= ×1.5

Area of Taipei
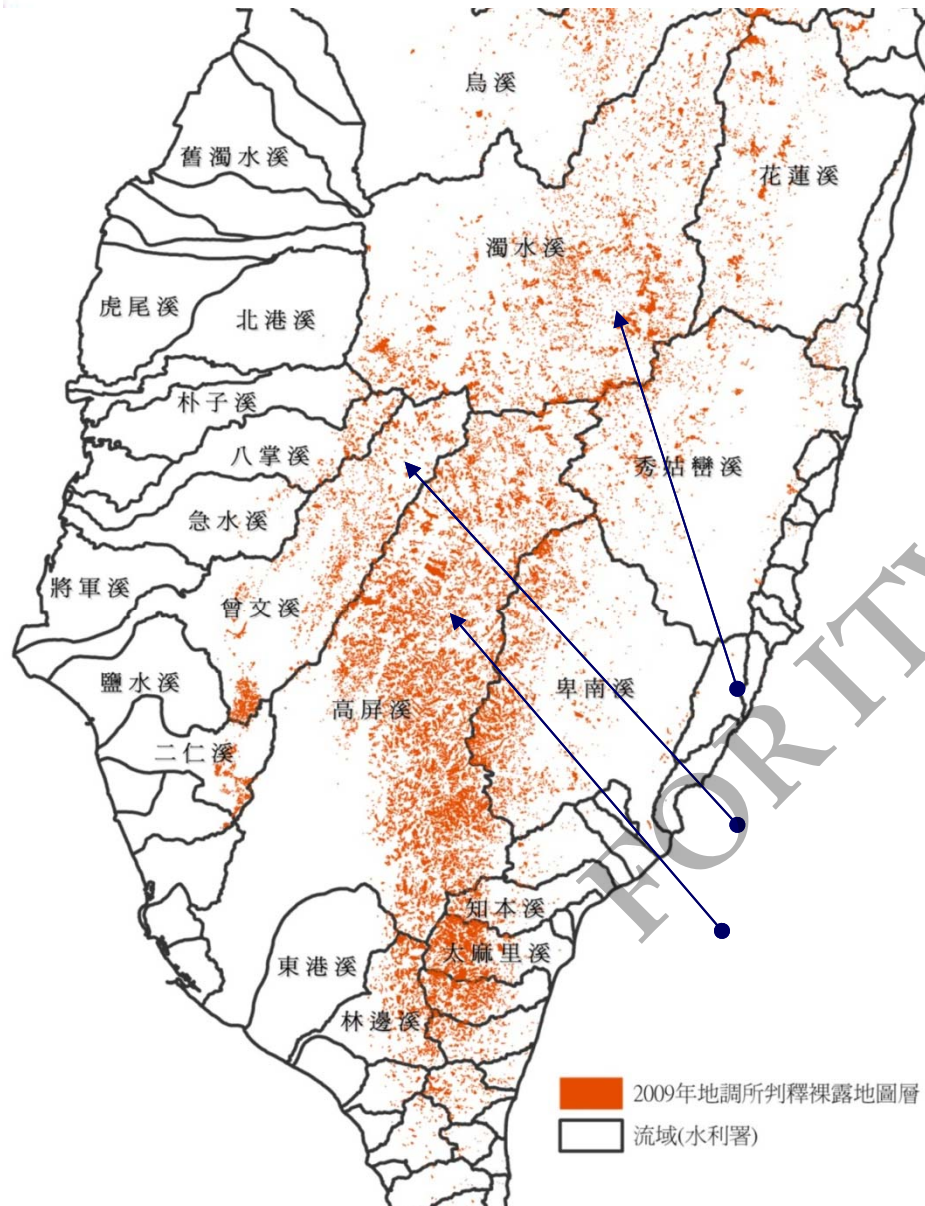
Before Morakot		After Morakot		Compare	
Count	Area (ha)	Count	Area (ha)	New Counts	Enlarged Area
3,717	5,652	10,579	13,657	**6,862**	**8,005**
607	820	2,576	3,868	1,969	3,048
3,335	3,993	14,765	22,667	**11,430**	**18,674**

2.1 Landslide of Large Scale

I = 98 mm/hr

R = 2342 mm

新發雨量站

I = 95 mm/hr
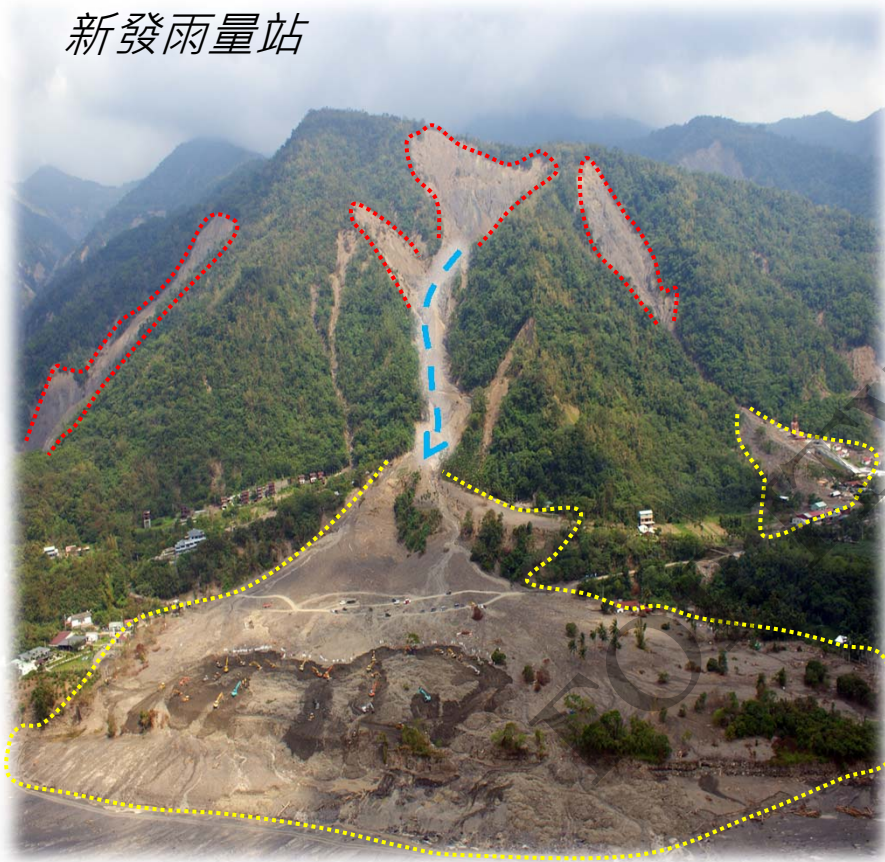
R = 2823 mm

御油山雨量站

Shinkai (新開) Village
32 killed at this area

Siaolin (小林)village
More than 400 killed at this area

Source: NCKU

2.1 Landslide of Large Scale (2)

The slopeland disaster after typhoon Morakot

Siaolin Villagethe hardest-hit area

1. In Jiasian Township of Kaohsiung County
2. 400 died and 53 missing
3. Landslide, barrier lake (dammed lake) and mudslide

Buried Area

Before

After

2.2 Debris Flow

Nagisalu (南沙魯) *Village*
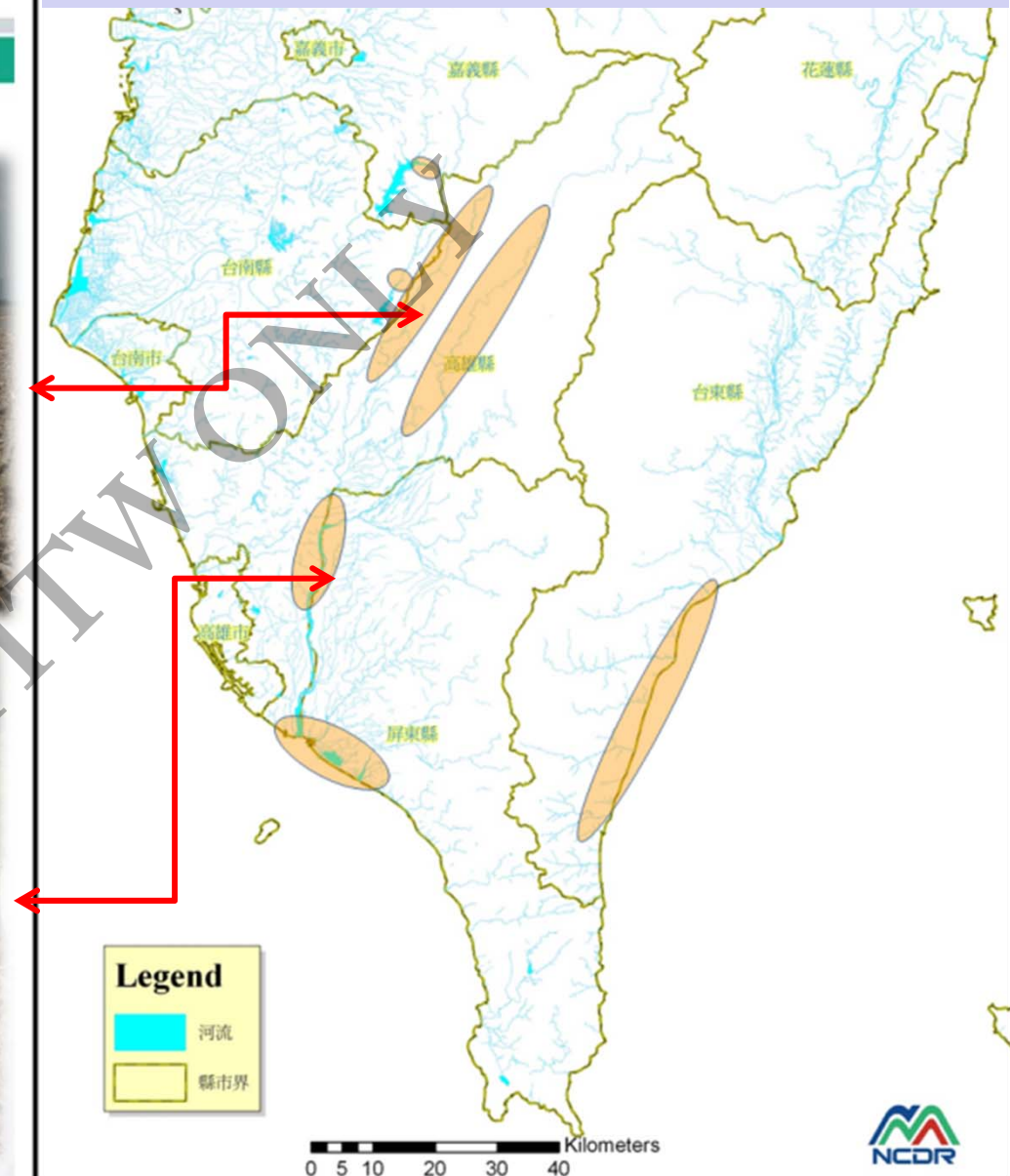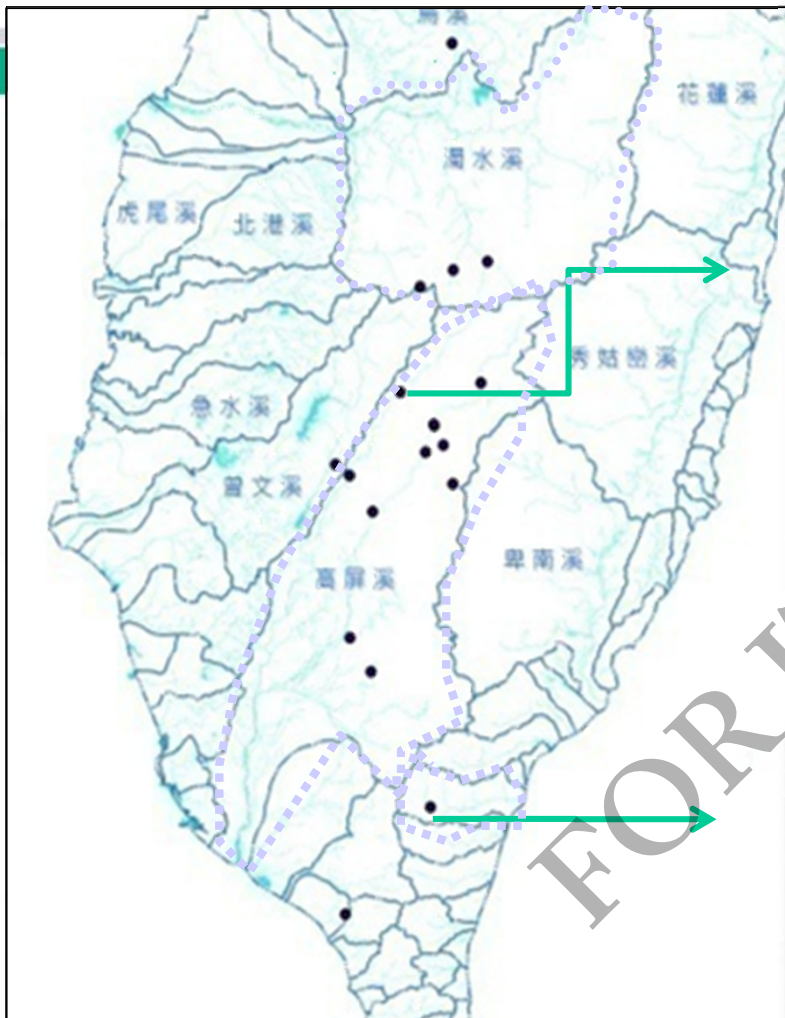*26 killed by the debris flow*

南沙魯 (民族村)

I = 88 mm/hr
R = 2074 mm
甲仙雨量站

2.3 Driftwood

Total amount of driftwood is about **1.33 million ton**
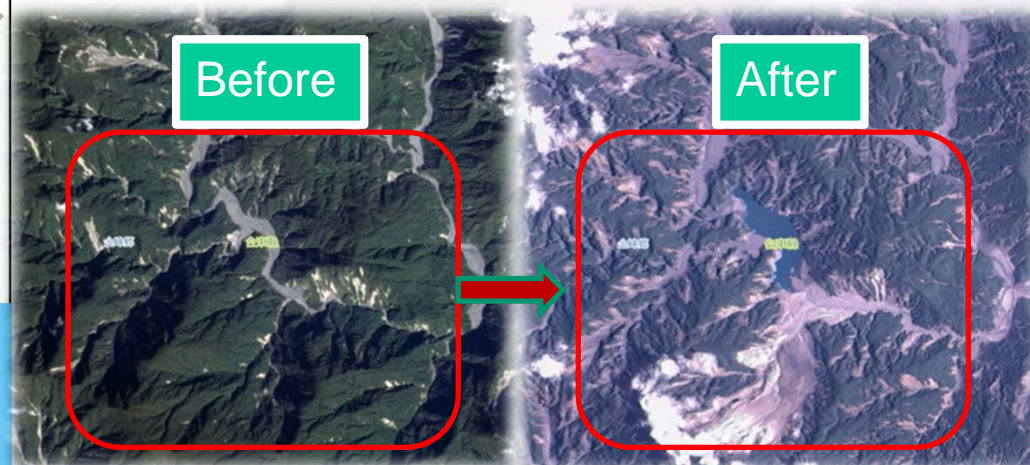
(Forestry Bureau)

Spatial distribution of driftwood

Legend

(cyan)	河流
(outline)	縣市界

Kilometers
0 5 10 20 30 40

2.4 Landslide Dam

Before → After

高雄縣旗山溪達卡努瓦村堰塞湖風災害前(左)後(右)福衛影像

Before → After

台東縣太麻里溪堰塞湖風災前(左)災後(右)之福衛影像

17 landslide dams were produced around on **Goping, Zhuoshui and Taimali** river

12

3. Summary problems by disaster

# 3. Summary problems by disaster

- **Disasters spread over a very large region (Over 5,000 km^2)**

1. **Large amount of sediment yield and movement (1.2 billion m^3)**

2. **Debris flow and landslides block rivers to form landslide dams.**

- **The collapse of roads cannot be fixed in short-term and cut off the communication with outside.**

4. Countermeasures for disaster

a. **Countermeasures for Disaster Response during typhoon event**

b. The investigation for large-scale landslide potential area
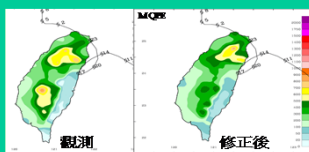
Process to identify the landslide potential
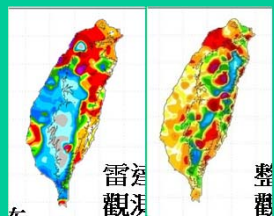
Rainfall information

QPESUMS estimation

Power mode

Climate mode

Siginificant Hillslope villages and Roadway
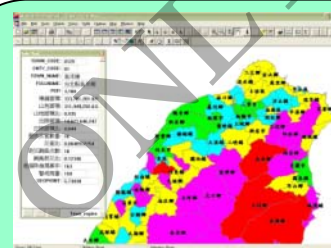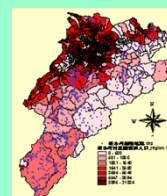
Debris flow potential torrent

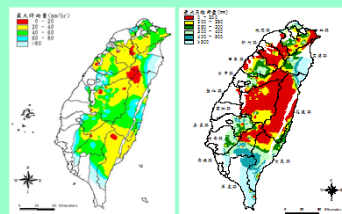Hillslope villages

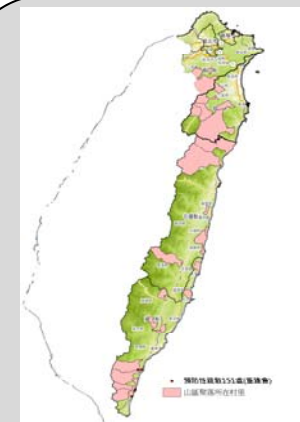Important Road

Threshold Value

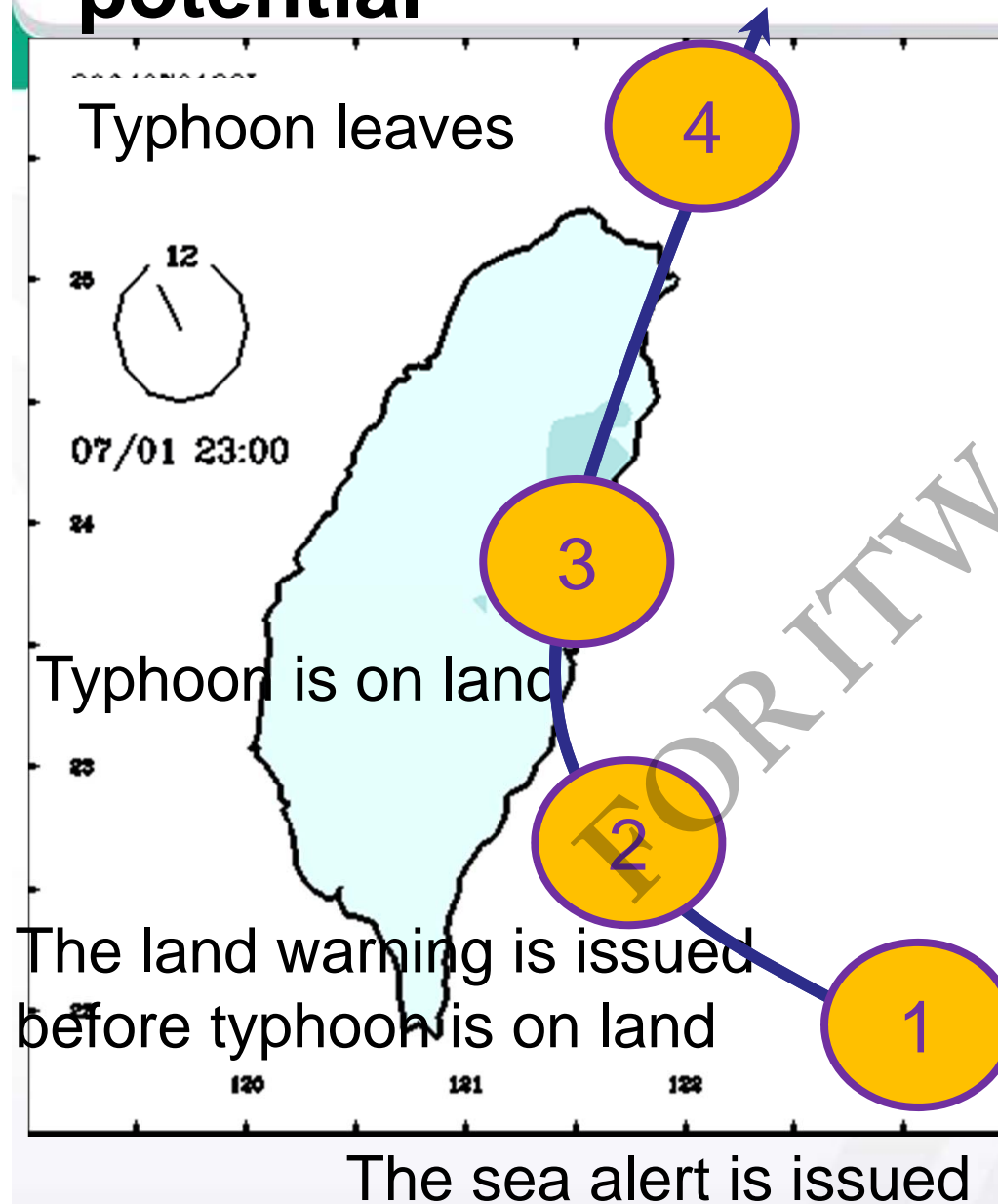Landslide potential

Elements at high risk

High vulnerability map

The analysis result

alert township and twice disaster in some zone propositions

Process to identify the landslide potential

Typhoon leaves

07/01 23:00

4

3

Typhoon is on land

2

1

The land warning is issued
before typhoon is on land

The sea alert is issued

Step 1
- Historical disaster spot analysis
- The analysis on hillslope disaster potential
- Hillslope disaster waring
- The pre-disaster relief .

Step 2, 3, 4
- Hillslope disaster warning information
- Roadway warning
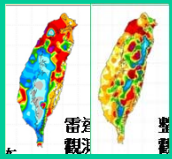
Process to identify the landslide potential

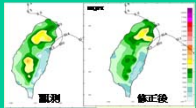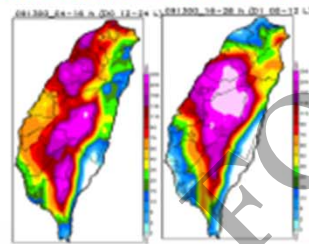| Rainfall information | Significant hillslope villages and Roadway | The threshold value | The analysis result |

QPESUMS estimation

Power mode

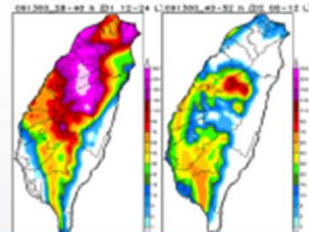Climate

颱風路徑潛勢預報圖
2010/10/17 14:00 LST

22日14時
21日14時
20日14時
19日14時
18日14時
18日02時
17日14時

0914 00-12L   0913 12-24L

0914 12-24L   0915 00-12L

WRF例行降雨預報

System Structure
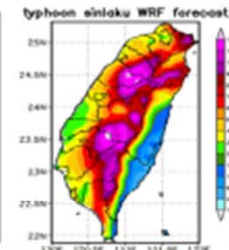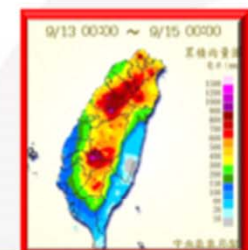
NCEP GFS Forecast Data → Initiation Process (WPS, 3DVar) → WRF → Output Dataset

CWB Official Predicted Typhoon Tracks Data → Check the Predicted Typhoon Tracks → Reproduce the predicted rainfall data

Support To Disaster Analysis

2008 SINLAKU   typhoon sinlaku WRF forecast

路徑修正颱風降雨   辛樂克颱風實際降雨

9/13 00:00 ~ 9/15 00:00

Rainfall estimation by analysis disaster risk from predicted typhoon track

FOR ITW ONLY

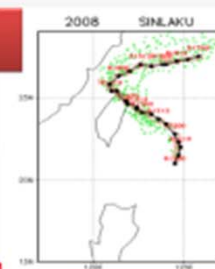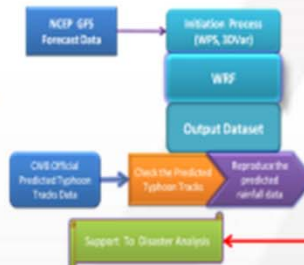# Process to identify the landslide potential

Rainfall information → **Significant hillslope villages and Roadway** → **The threshold value** → **The analysis result**

Debris flow

Landslide rainfall threshold

Road disrupt
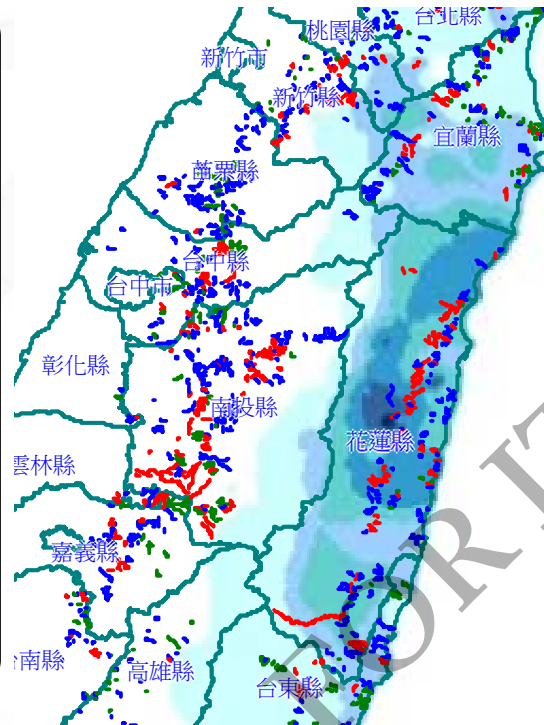
Potential Debris Flow Areas managed by Soil and water conservation bureau

縣市界
山坡地界址圖
山坡地鄉鎮
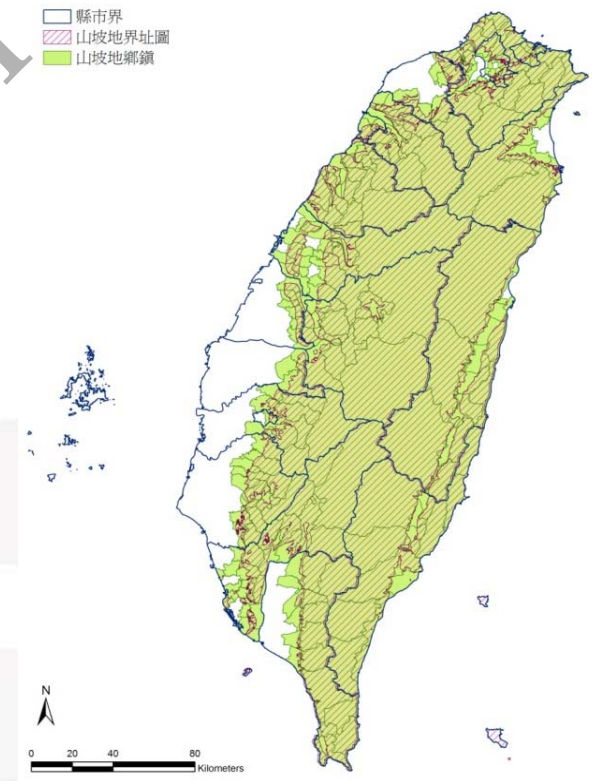
228 hillslope counties

Process to identify the landslide potential

Rainfall information

Significant hillslope villages and Roadway

The threshold value

The analysis result

Debris flow

Landslide rainfall threshold

Road disrupt

颱風路徑二
易致災道路潛勢

台7
台北市 基隆市
台7甲
台北市
新竹市 宜蘭縣
台8 新竹縣
台14 苗栗縣
台9 蘇花路段
台21
南投縣 台9 花東路段
花蓮縣
雲林縣
台18
嘉義縣
台20
台南市
台21
台20
台27
高雄市
屏東縣
台24
台9 南迴路段

Legend
易致災省道
低
中
高

10 Significant roadways

The disrupted road information from Directorate General of Highways

地圖

災害名稱： 980805莫拉克颱風
路線樁號： 縣162甲線42K+800~43K+0
附近地名： 太和村
受損狀況： 路基流失約200公尺
災害發生時間： 2009/8/10 上午 08:00:00
預計搶通時間： 2012/8/31 下午 05:00:00
交通影響情形： 未全面通車

彰化縣
雲林縣 花蓮縣
嘉義市 嘉義縣
台南市
高雄市 台東縣

Google | 50公里
20英里
地圖資料 ©2012 Google, Kingway, Mapabc, ZENRIN - 使用條款

單一道路 交叉路口 重要地標 地址定位
俗名查詢 里程數 全螢幕

Process to identify the landslide potential

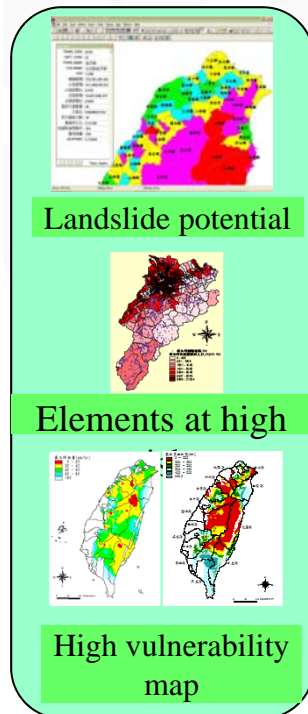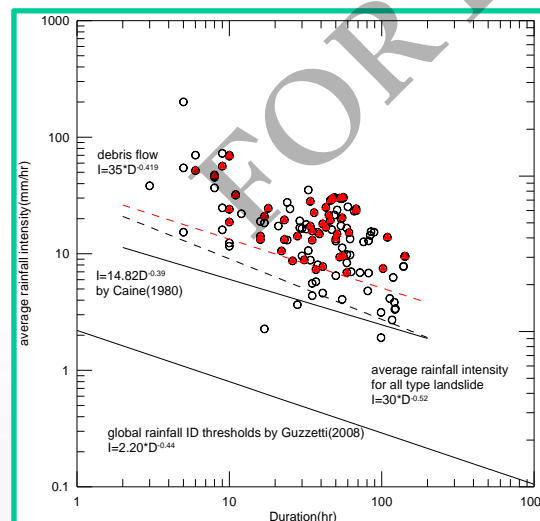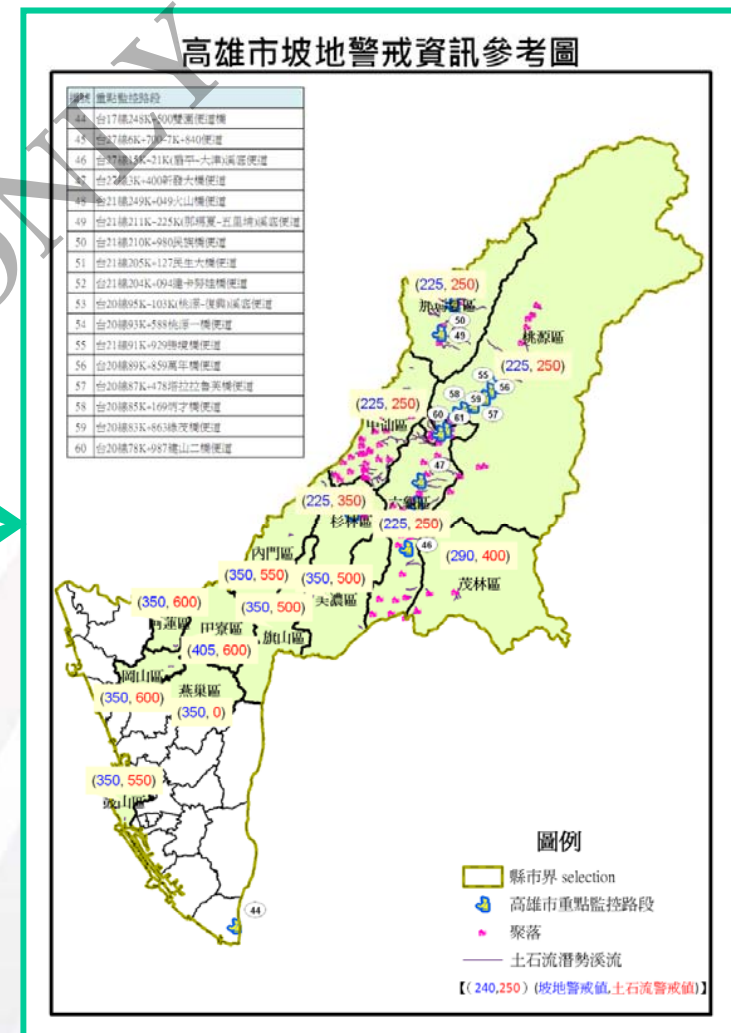| Rainfall information | Significant hillslope villages and Roadway | The threshold value | The analysis result |

The value is modified each year

Landslide potential

Elements at high

High vulnerability map

各縣市坡地災害警戒值_100年更新

縣市	舊警戒值	30%	40%	50%	60%	70%	80%	90%
北北基	400	106	150	200	270	340	430	565
桃園縣	300	100	180	310	445	600	720	1040
新竹縣	300	120	210	290	370	460	565	730
苗栗縣	300	100	160	250	325	415	520	680
台中縣	300	100	135	180	225	275	335	425
彰化縣	300							
晉林縣	300							
嘉義縣	400	240	315	380	450	525	610	750
台南縣	250	205	270	330	385	450	525	640
高雄縣	300	225	290	350	405	470	545	660
屏東縣	350	255	295	330	370	410	460	530
宜蘭縣	400	100	195	300	385	505	640	840
花蓮縣	350	100	150	240	380	525	705	980
台東縣	400	110	175	230	290	255	430	550
南投縣	200	100	145	190	230	285	345	435

下調   上修

高雄市坡地警戒資訊參考圖

debris flow
$I = 35 \cdot D^{-0.419}$

$I = 14.82 D^{-0.39}$
by Caine(1980)

average rainfall intensity
for all type landslide
$I = 30 \cdot D^{-0.52}$

global rainfall ID thresholds by Guzzetti(2008)
$I = 2.20 \cdot D^{-0.44}$

average rainfall intensity(mm/hr)

Duration(hr)

Statistical analysis

圖例
縣市界 selection
高雄市重點監控路段
聚落
土石流潛勢溪流
【(240,250) (坡地警戒值,土石流警戒值)】

Process to identify the landslide potential

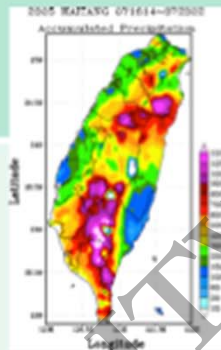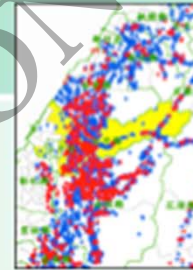| Rainfall information	Significant hillslope villages and Roadway	The threshold value	The analysis result

alert township and twice disaster in some zone propositions

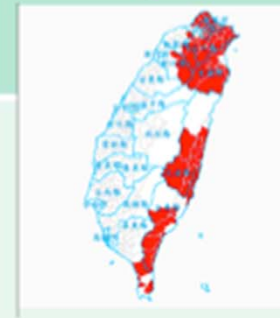Web based information system
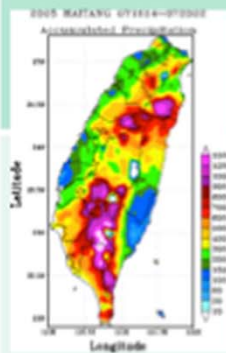
Real-time rainfall
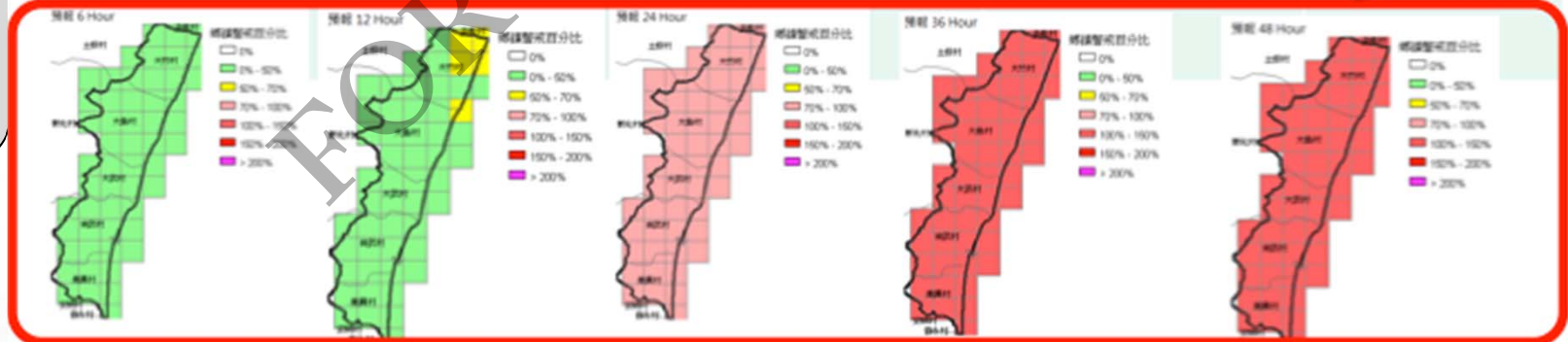
Estimated rainfall

Landslide with high potential

Warning areas (Real-time rainfall)

Warning areas (Estimated rainfall

- The result is analyzed by different statistical methods.
- The warning areas is different based on the scenario is determined.

4. Countermeasures for disaster

a. Countermeasures for Disaster Response during typhoon event

b. **The investigation for large-scale landslide potential area**

Post-disaster actions: on-site field survey

Investigation Content

Historical event:

Location

Affected range

Magnitude

Rainfall amount

Hazard-prone area:

Geologic survey

River Terrace

Old landslide
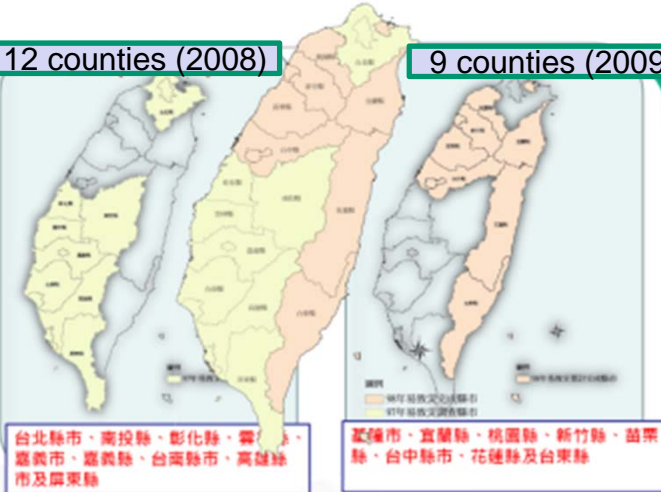
Artificial Slope,

retaining wall

Digitalized survey data

NCDR

12 counties (2008)   9 counties (2009)

台北縣市、南投縣、彰化縣、雲林縣、嘉義市、嘉義縣、台南縣市、高雄縣市及屏東縣

基隆市、宜蘭縣、桃園縣、新竹縣、苗栗縣、台中縣市、花蓮縣及台東縣

After typhoon Morakot :

Ten Counties in Southern part were focued

Investigation Content

Hazard-prone area (Flood and slopeland disaster)
Tribe
Roadway and Bridge
Infrastructure for flooding
Shelters
Distribution of relief resources
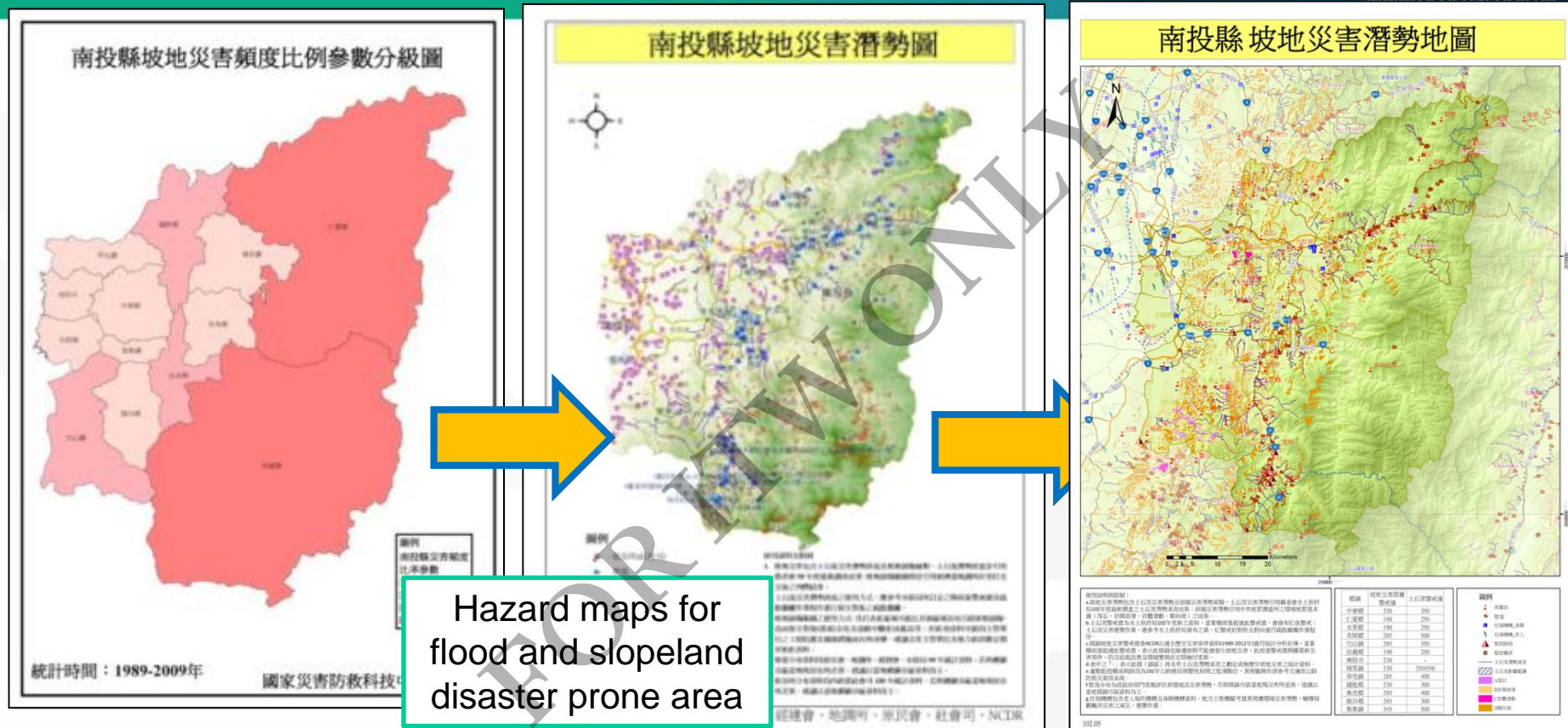
| Hazard-prone area Survey | + | Tribe location | + | Hazard-prone roadway or bridge | → | The hazard-prone area |

阿里山鄉坡地易致災現地調查地圖

Tribe location

Fragile bridge

Hazrd-porne area

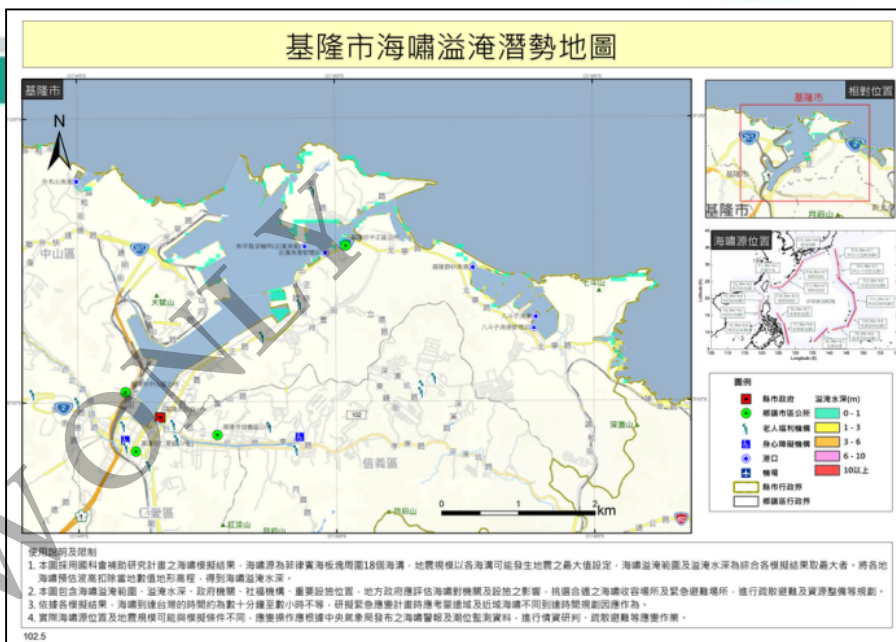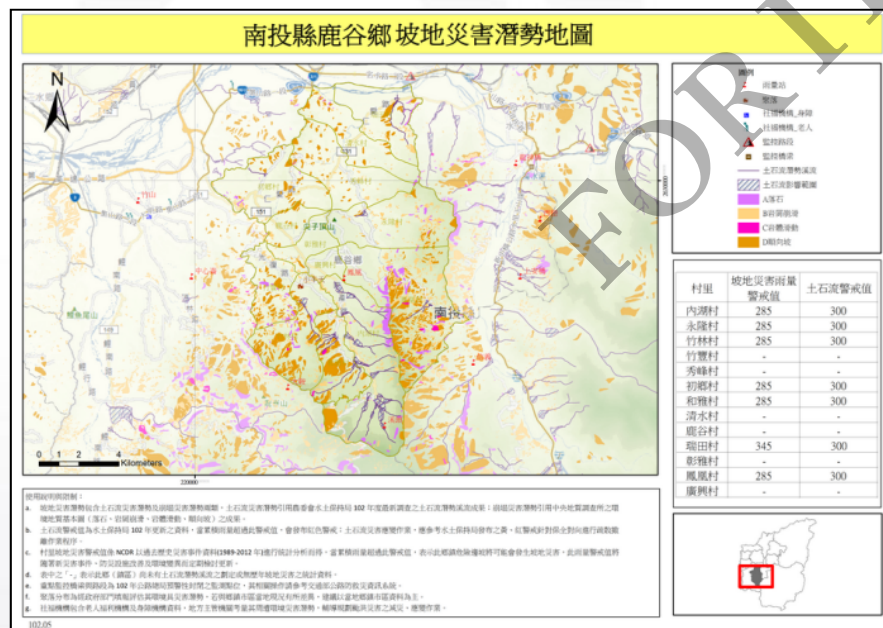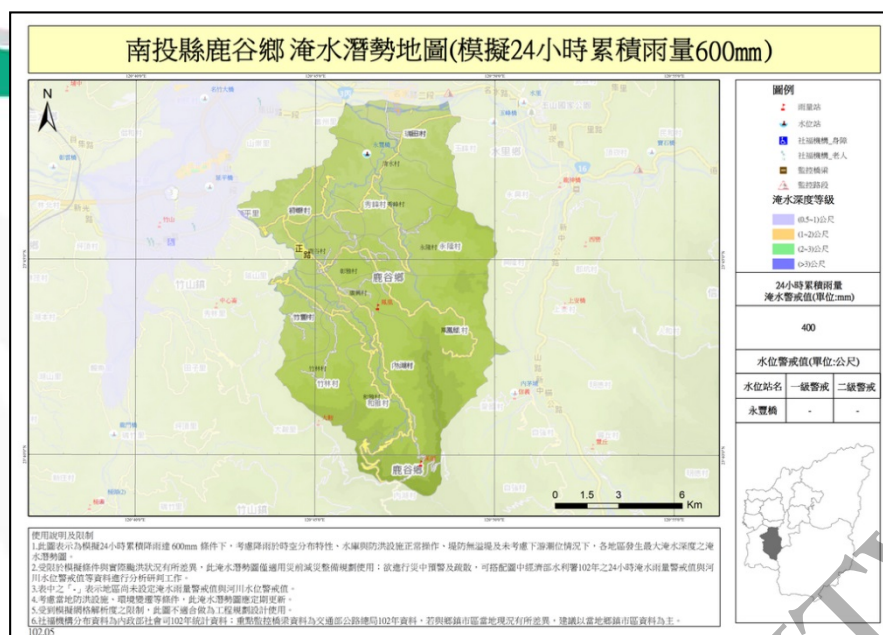# Hazard map for flood and slopeland disasters
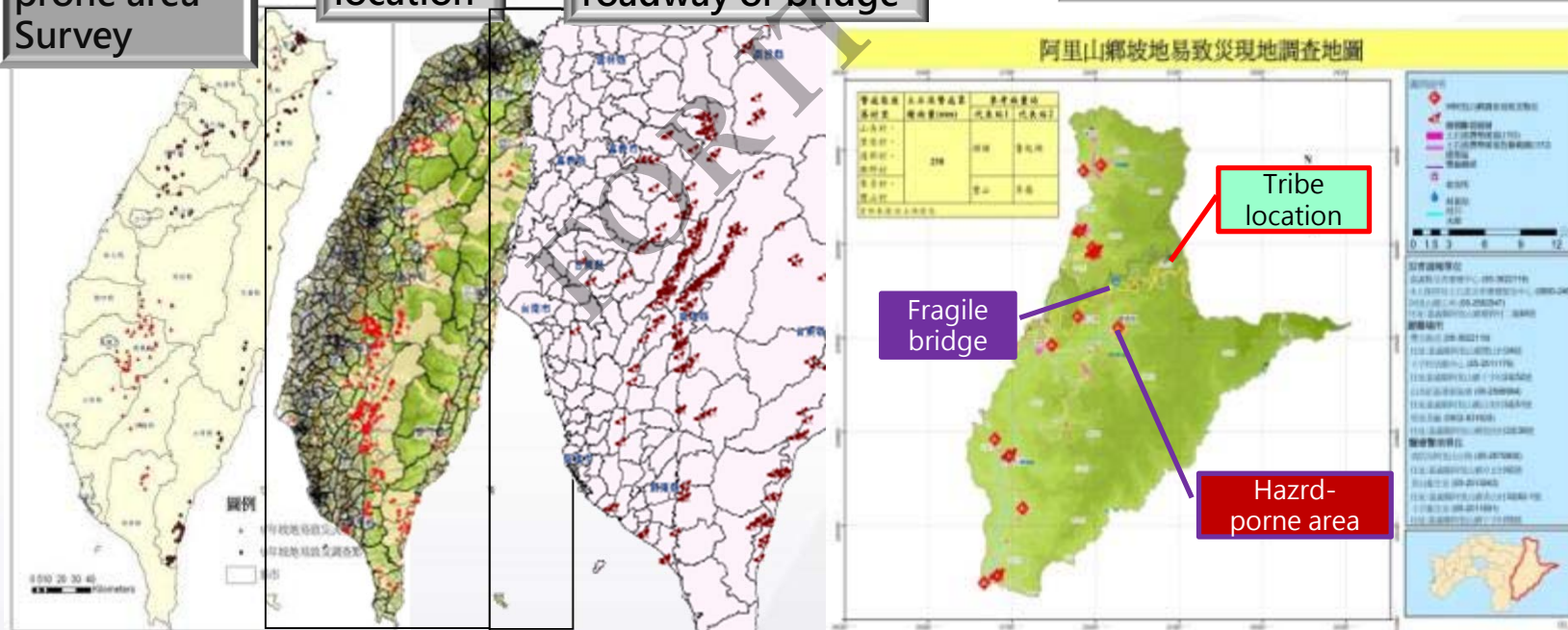
Hazard maps for flood and slopeland disaster prone area

Over 1,600 hazard maps were produced with different scale, type of hazards, and for different users.

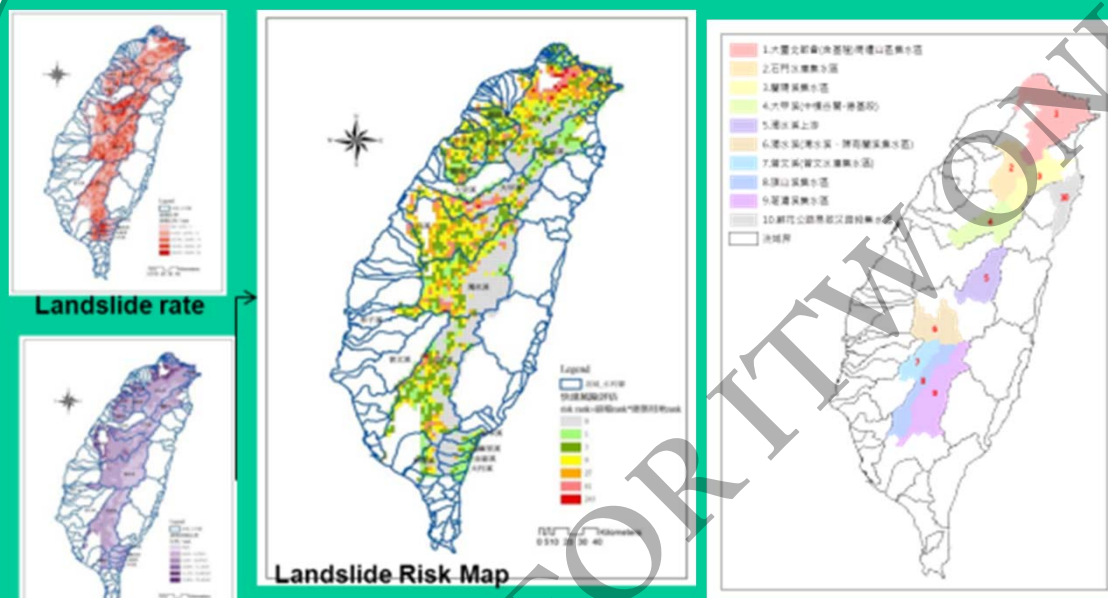# Hazard map for flood and slopeland disasters

Basically, flood, slopeland, and tsunami disasters are the main disasters we concern. These maps were produced and modified every year.

Development of large-scale landslide risk reduction

Large-Scale Landslide Potential Classification

Landslide rate

Vulnerable data map

Landslide Risk Map
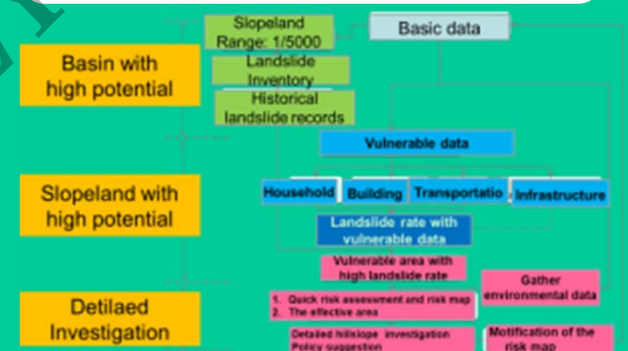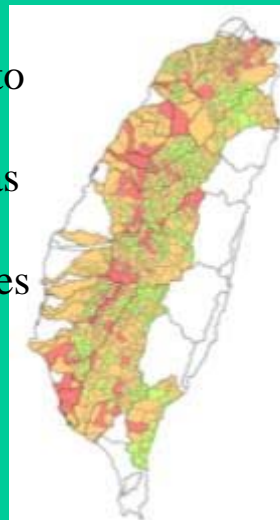
• Large-scale landslide classification is precede by landslide rate and digitalized data of **tribe and roadway**.

•10 catchments were classified at the first stage.

Basin scale classification

Provided the result for government sectors

• The framework to classify the large-scale landslide was provided to hillslope authorities to check their manage area

Sub-basin scale

6. Conclusion

6. Conclusion

1. **Typhoon Morakot brought us the experience of slopeland disaster with different types induced by the extreme weather which was never happened in the past.**

2. **The method to identified the large-scale landslide has been utilized. Totally 10 area has been confirmed. The further research is proceeding to investigating the slopeland with high potential of landslide.**

Thank You for Your Attention!

Disasters always knock at a door when we are slacking