

TRANSDISCIPLINARY APPROACH OF RISK GOVERNANCE AND THE PREVENTION OF SEDIMENT DISASTERS AFTER A MEGA EARTHQUAKE – AN EXAMPLE OF THE 0403 EARTHQUAKE AND THE AFTERMATH TYPHOON EVENTS IN 2024, EASTERN TAIWAN



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OUTLINE

Introduction

0403 Earthquake and it's Impact

Sediment Disasters after Mega Earthquake

Risk Governance and Disaster Prevention with Transdisciplinary Approach

2024 Typhoon Events

Conclusions & Ongoing Challenges

01

Introduction

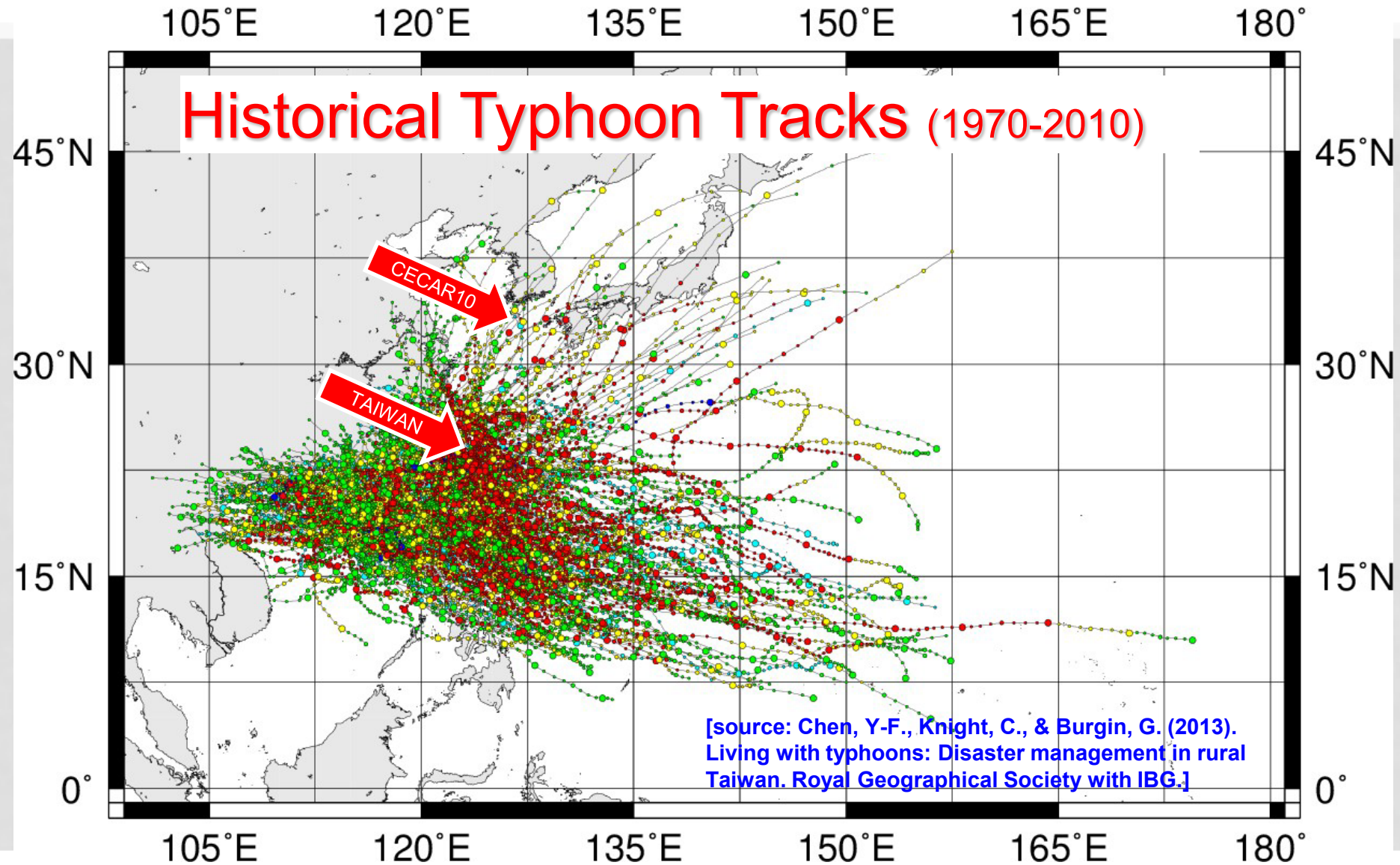
– Sediment Disaster in Taiwan



Historical Earthquakes around Taiwan



INTRODUCTION



Landslide



Rock fall



**Landslide
Lake**

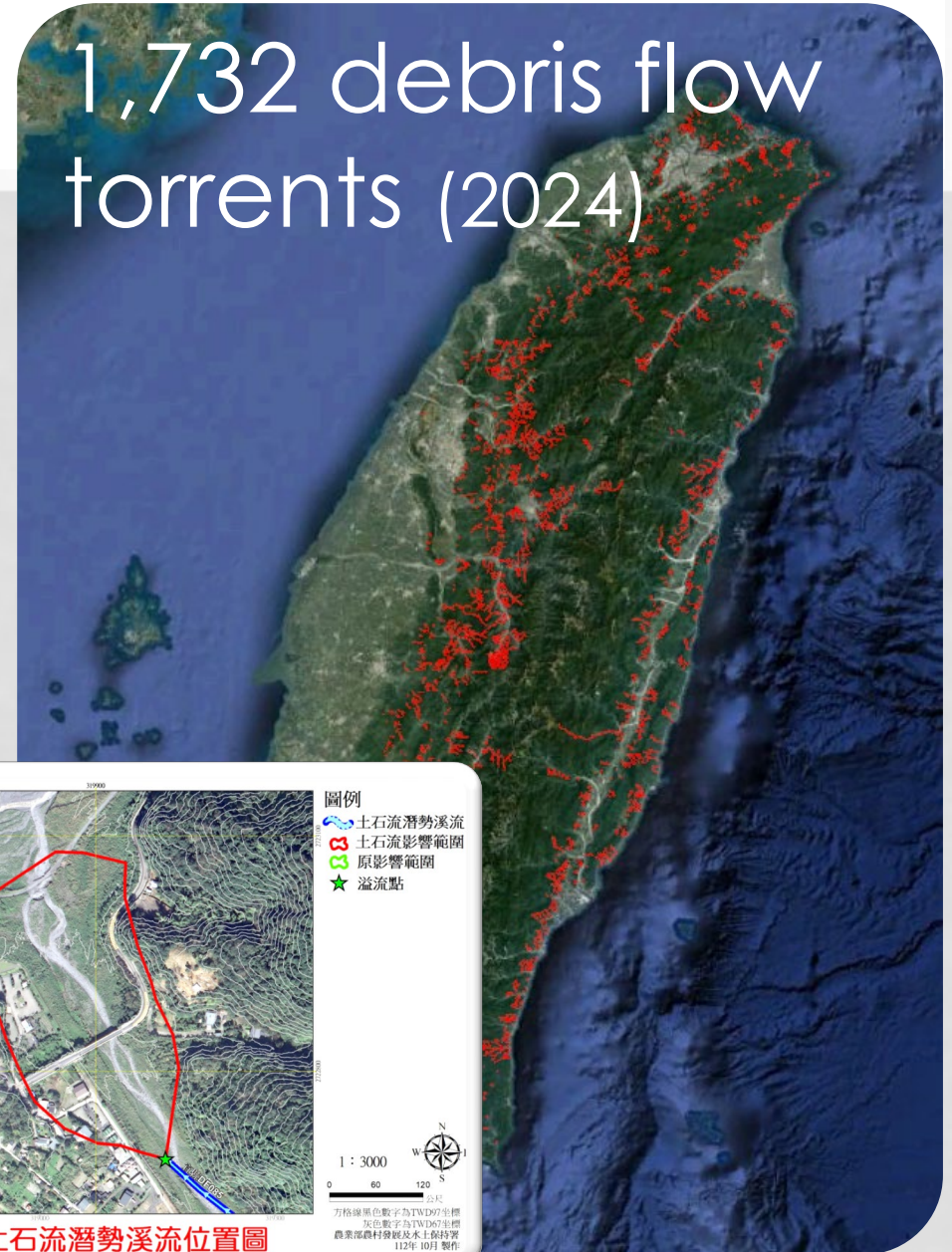
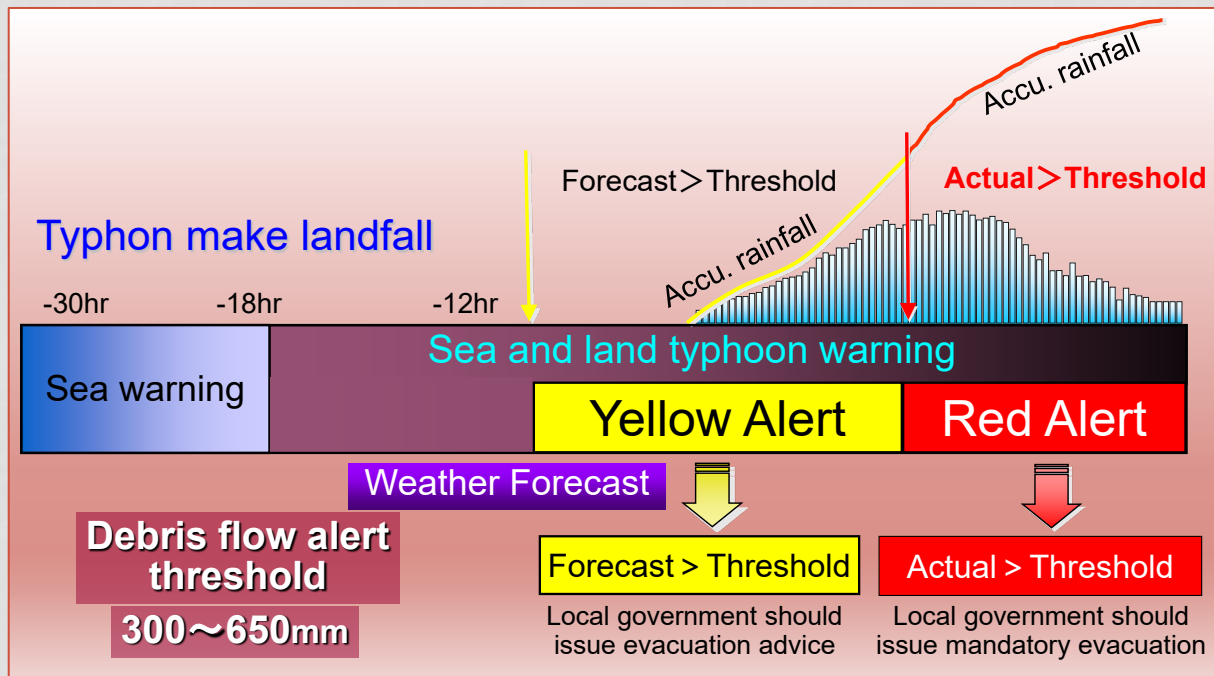


Debris flow



Disaster Response

Red/Yellow Alert during Typhoon

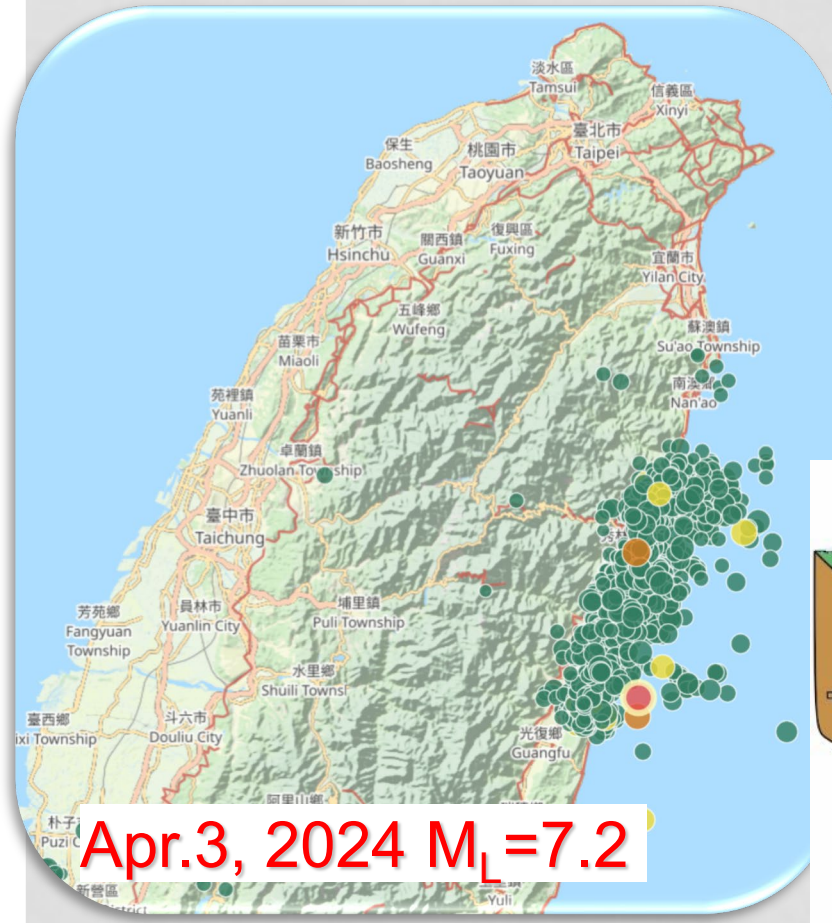


02

0403 Earthquake and it's Impact

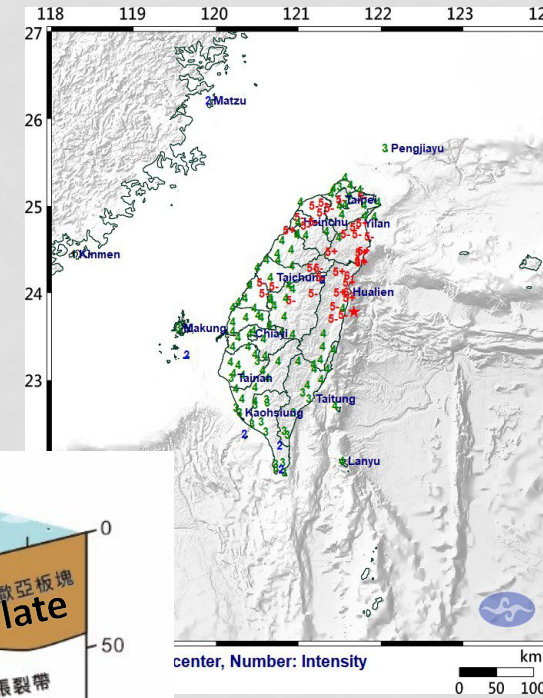
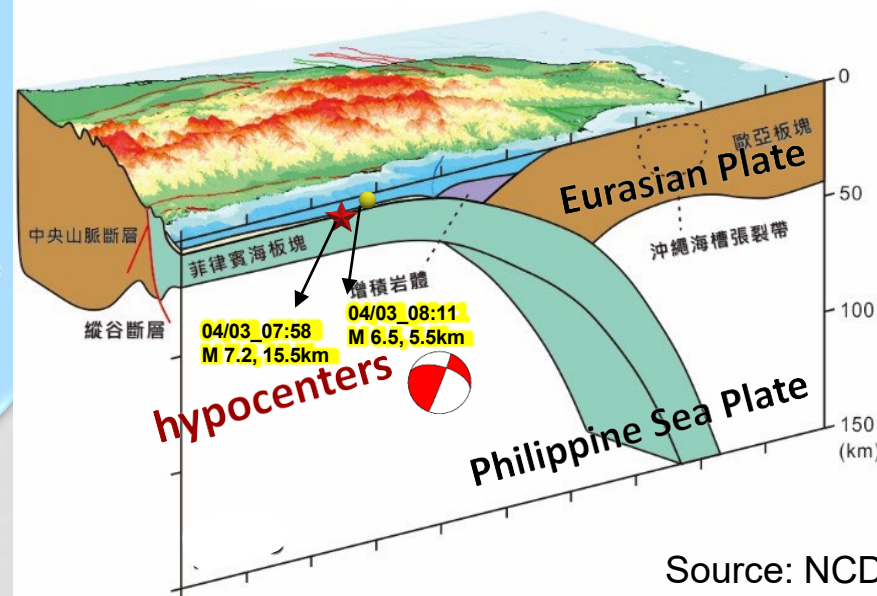
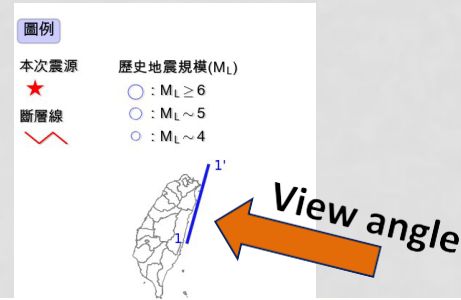


0403 Earthquake (07:58 AM, Apr.3, 2024, $M_L=7.2$)



Apr.3, 2024 $M_L=7.2$

Source: USGS



CWA EARTHQUAKE REPORT

Earthquake No.: 113019

Origin time (Taiwan Standard Time: GMT+8):

4/ 3/2024 7:58: 9.9

Epicenter: 23.77°N, 121.67°E,
i.e. 25.0 km SSE of Hualien County Hall

Focal depth: 15.5 km

Magnitude (M_L): 7.2

Local Largest Intensity:

Hualien County	6+	Hsinchu City	4
Yilan County	5+	Tainan City	4
Miaoli County	5+	Keelung City	4
Taichung City	5-	Pingtung County	4
Changhua County	5-	Penghu County	3
Hsinchu County	5-	Lienchiang County	2
Nantou County	5-	Kinmen County	1
Taoyuan City	5-		
New Taipei City	5-		
Taipei City	5-		
Taitung County	4		
Chiayi County	4		
Yunlin County	4		
Kaohsiung City	4		
Chiayi City	4		

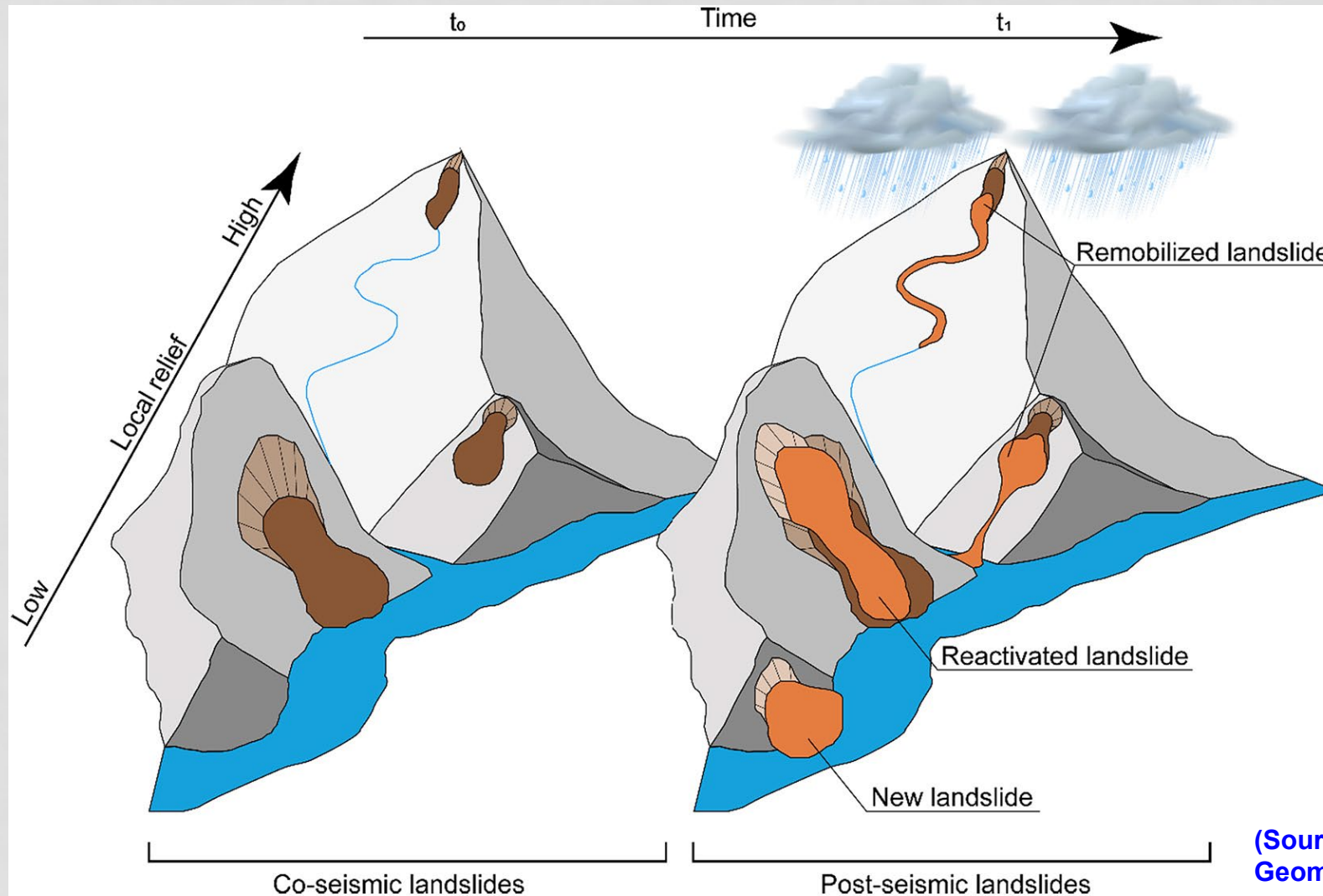
0403 Earthquake (Apr.3, 2024, $M_L=7.2$)



2024年4月3日 08:58:23
24°9'41.22"N 121°39'25.04"E

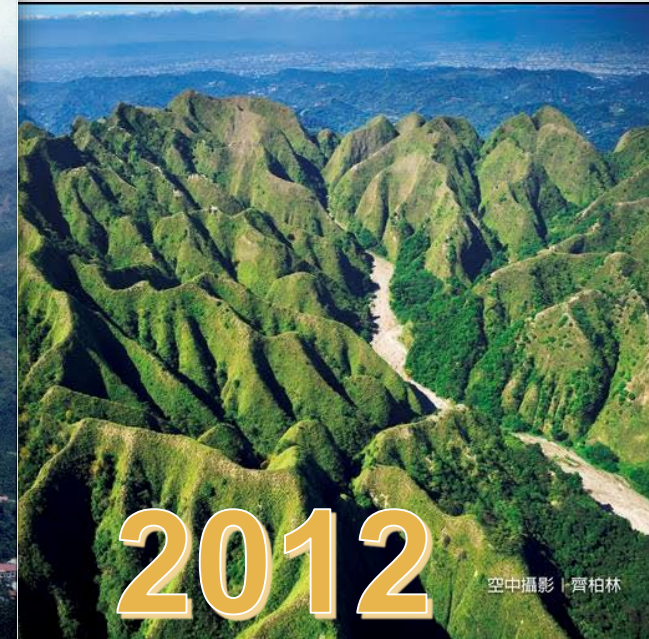
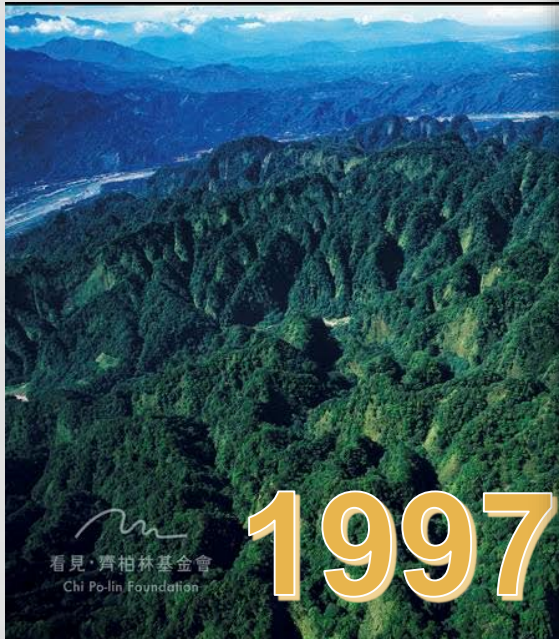
Source: Formosa TV

Earthquake Triggered Landslides and Aftermath



(Source: Tanyas et al. (2021),
Geomorphology 391 107912)

Earthquake Triggered Landslides and Aftermath



(Source: Chi Po-lin Foundation)

03

Risk Governance and Disaster Prevention with Transdisciplinary Approach



Challenges – new disaster type and MUCH BIGGER



Challenges – new disaster type

Residents

Where are the dangerous areas?

Risk identification,
Hazard mapping

When should I evacuate?

Update red warning,
Cell broadcast

Who is going to explain these to me?

Local information meeting

Railway Co., Highway Bu.

Would my facilities be affected?

When should I shut off the railway/road?

How could I utilize these information?

Challenges – time is limited

0403 Earthquake



Up to 500~700mm

JAN

FEB

MAR

APR

MAY

JUN

JUL

AUG

SEP

OCT

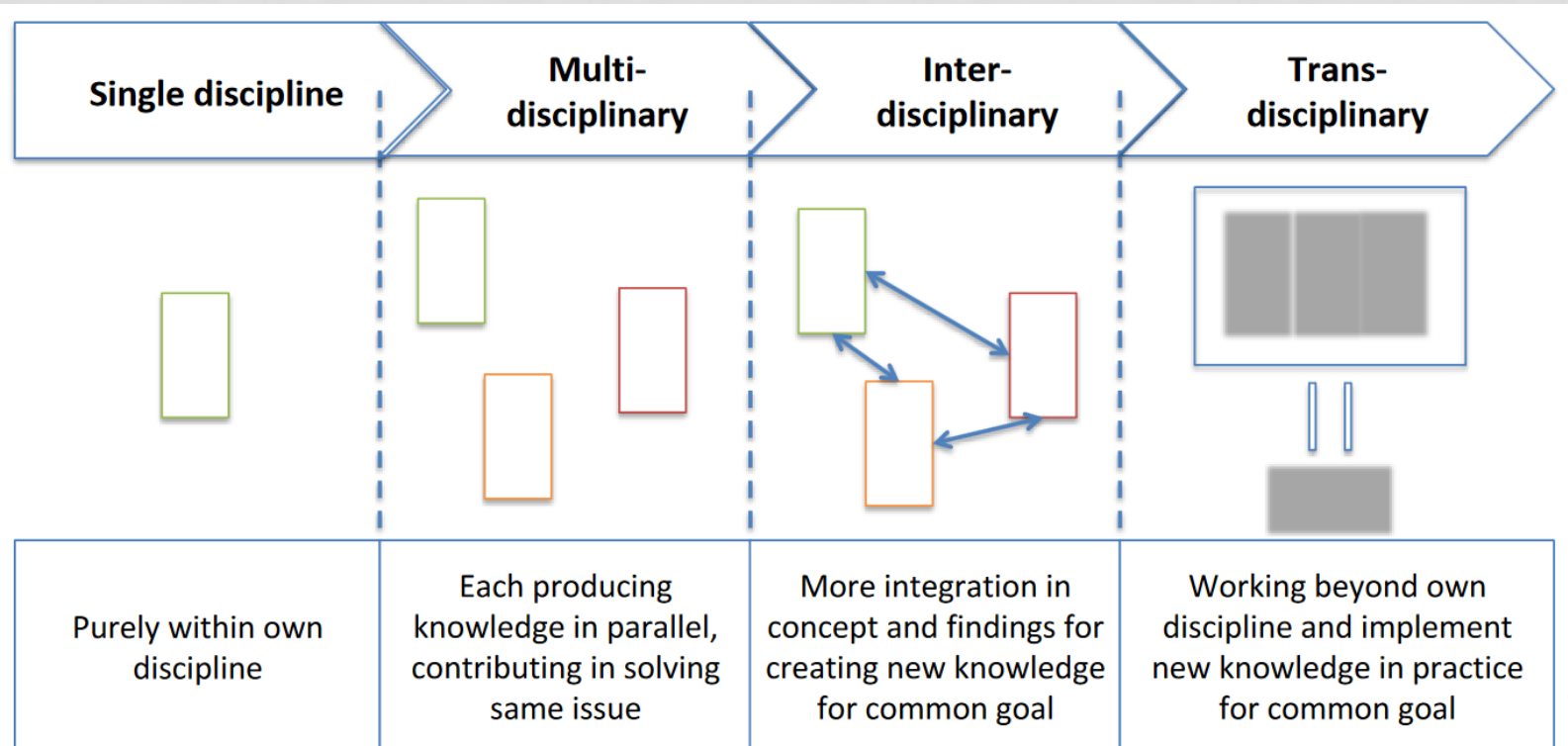
NOV

DEC

Flood (typhoon) season

Transdisciplinary Approach

- ✓ Approach to solve multi-sector/stakeholder problems
- ✓ Based on science and technology findings
- ✓ Collaboration from public, private and civil sectors

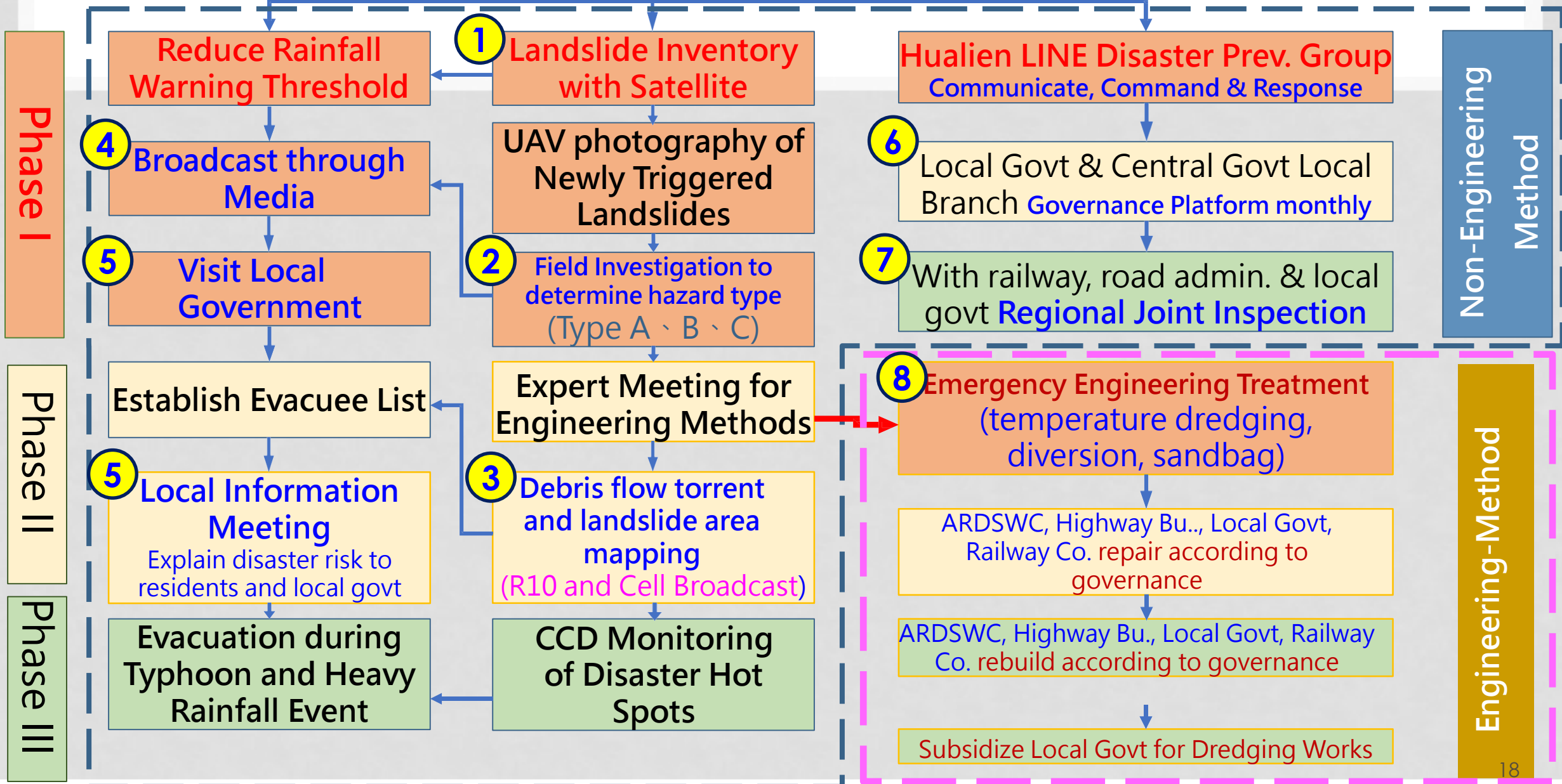


(Source: Matsuura and Razak (2019), *Disaster Prevention and Management* 28 (6): 817-830)

Disaster Response

0403 E.Q. and Rainfall Event Treatment Procedure

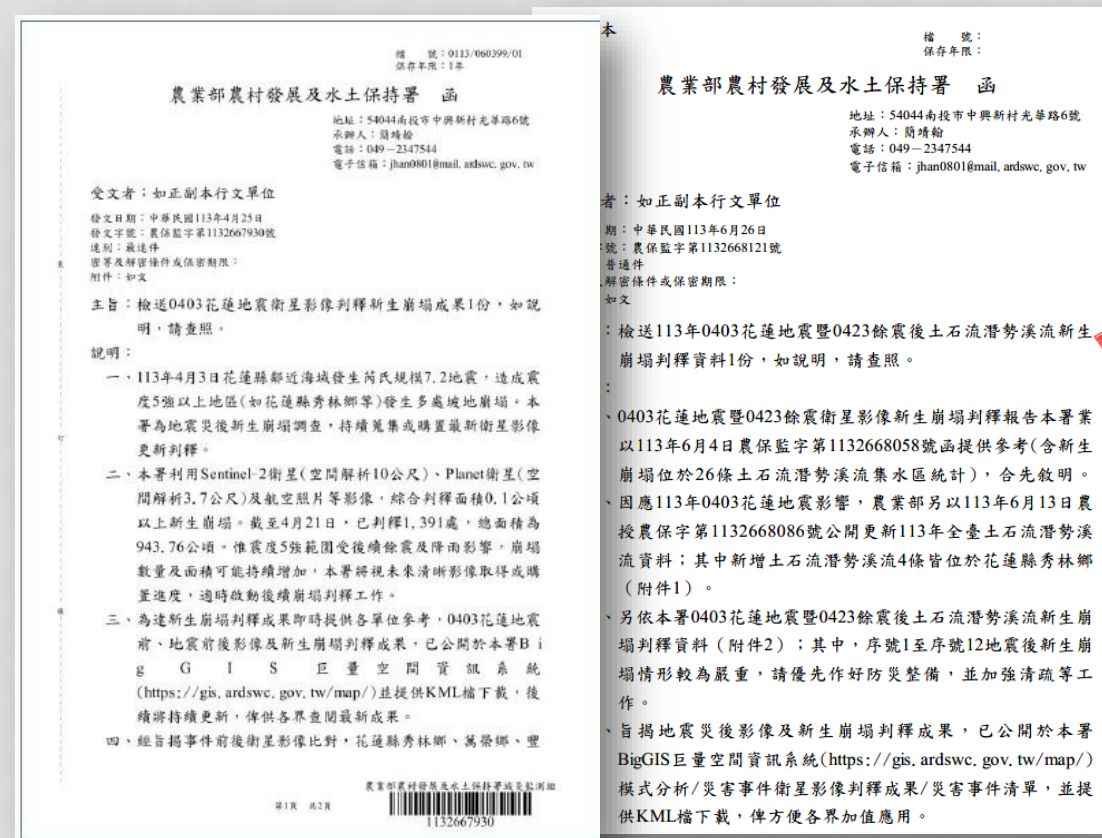
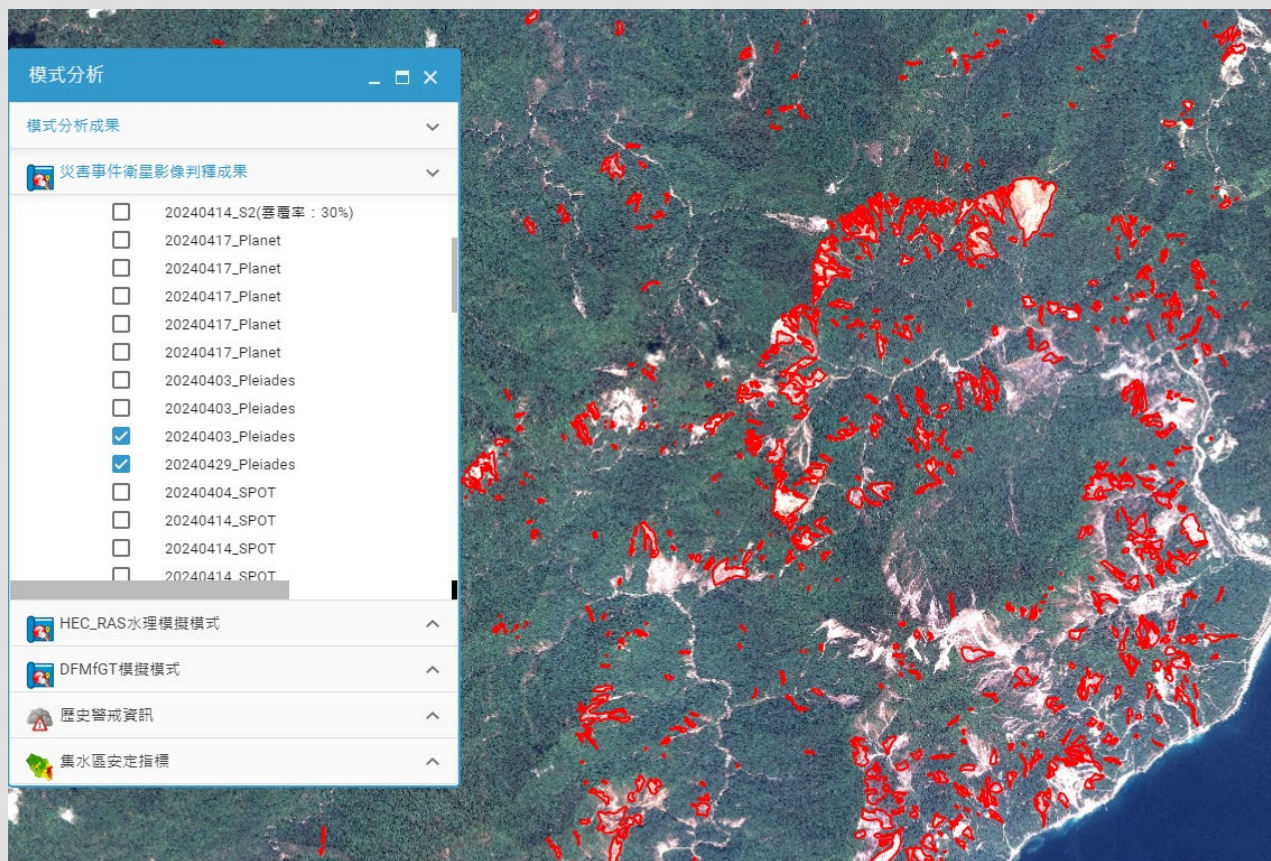
Regional Joint Defense





Landslide Inventory with Satellite

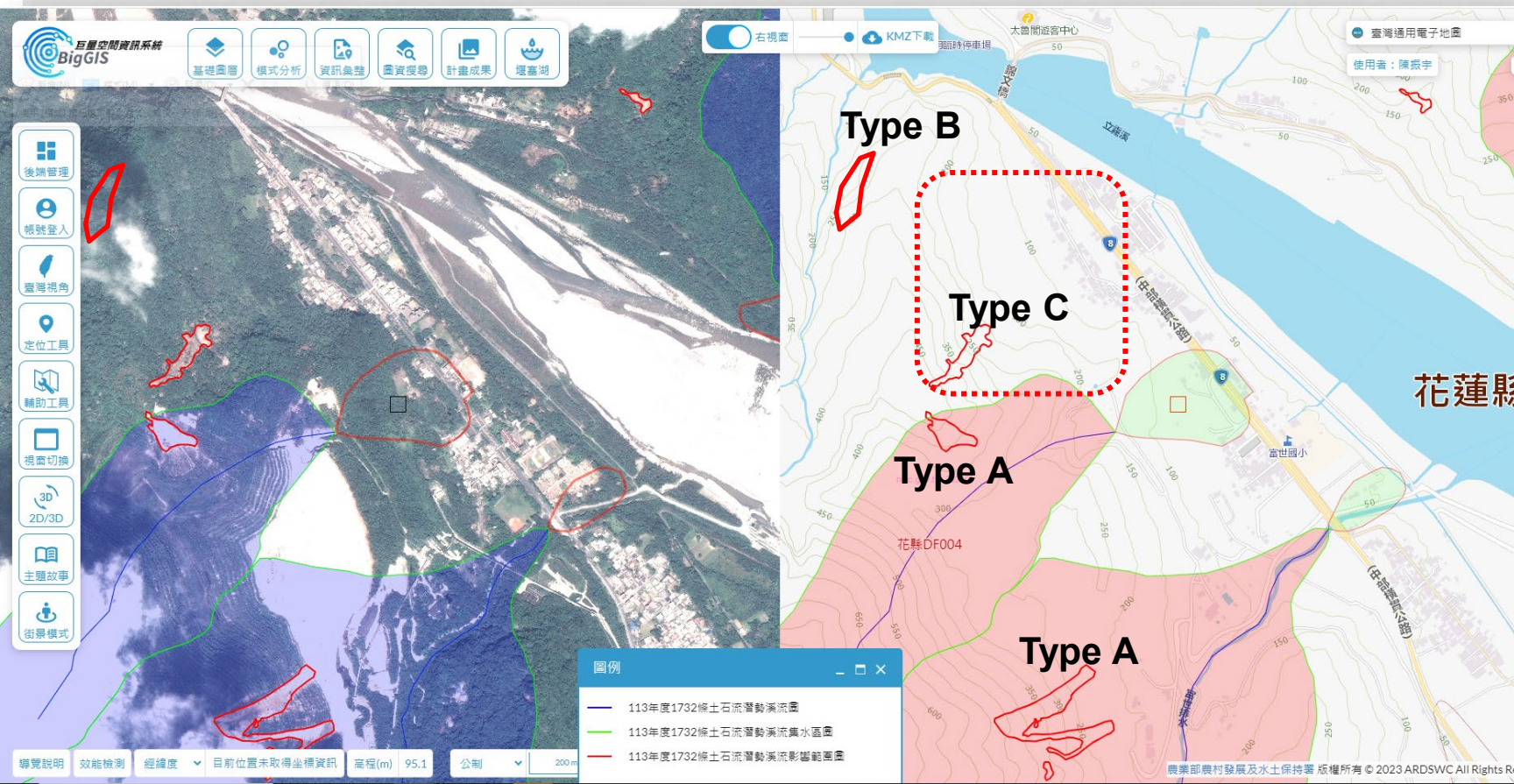
- **1,942** new landslides (1,521 Ha) identified with satellite image up to May 31.
- Updated regularly and **FREE Download** on web.
- Notify **Railway Co., Highway Bu., Forest Bu.** and other agencies since Apr.



2

Field Investigation to Determine Hazard Type

- Type A: Landslide falls **within current DF**; update risk level, reduce alert threshold.
- Type B: Landslide falls **within torrent catchment**; add as new DF.
- Type C: Landslide falls **on slope**; add as **Sediment Sensitive Area**.



Hualien SL0014



Hualien SL0001



Type C

L=370m

H=515m

No. 63, 65,
67, 69, 71

100m

54°

Train
Station

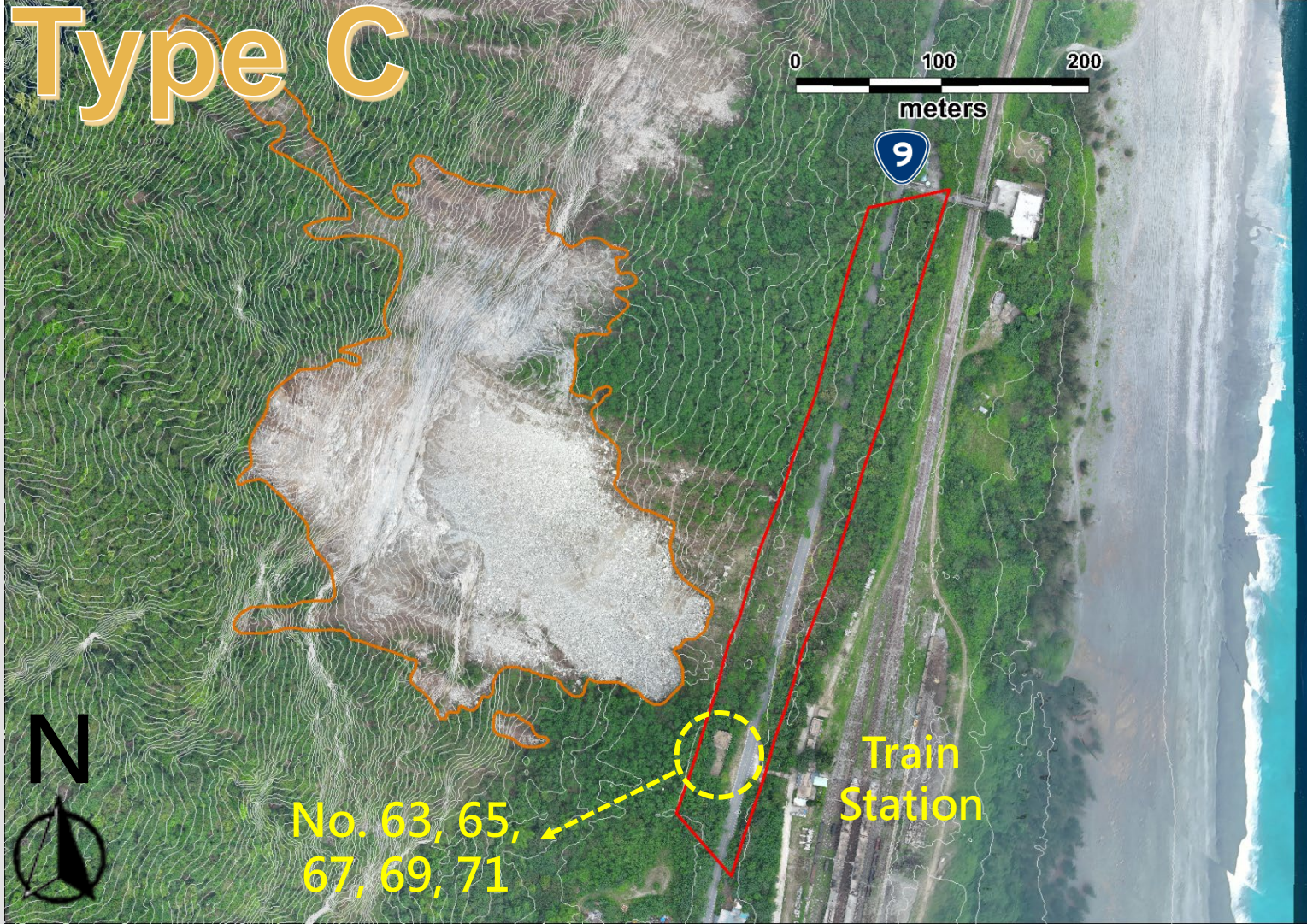


Landslide

Slope

30°
2ΔH or
Max. 50m

Affected
Area



- Landslide Affected Area
- 0403 Landslide

Chongde Vil., Hualien County
Houses: 5
LS Area: 7.43 Ha
LS Slope: 45~60 degrees
LS History: 0403 EQ, 2024
Image Date: Apr. 2024

15 were mapped by
May 1st
45 by **May 30th**

Hualien SL0002 Landslide Hazard Map

3

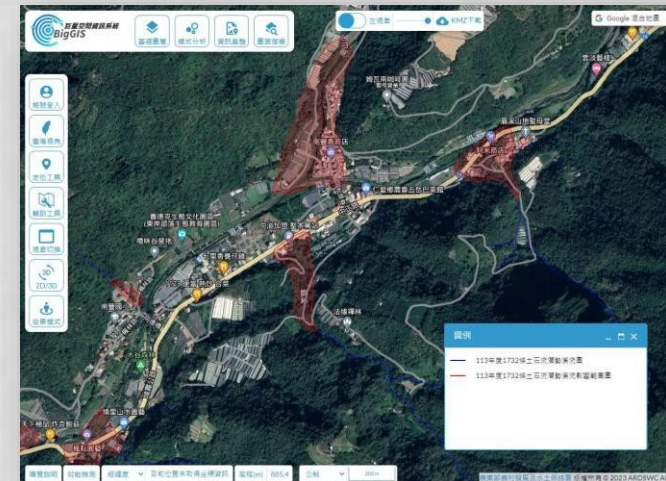
Debris Flow Torrent Hazard Mapping

Debris Flow Information Update

- ✓ 1,732 + 4 Debris flow torrents
- ✓ 4 newly added in EQ area in June
- ✓ Adjust rainfall threshold

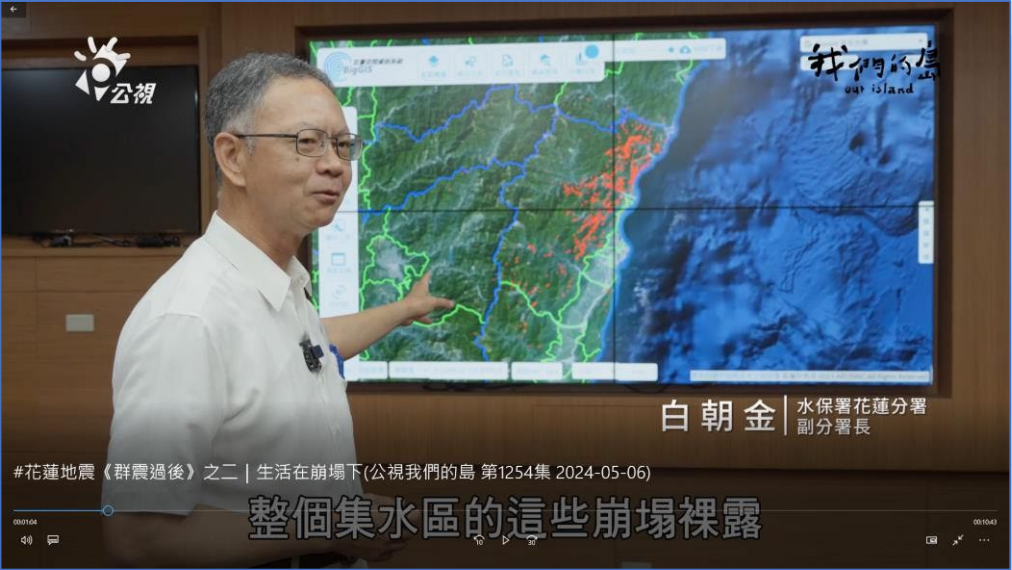
Publicity

- ✓ Public on line
(<https://246.ardswc.gov.tw/>)
- ✓ BigGIS(<https://gis.ardswc.gov.tw>)
- ✓ TGOS (<https://www.tgos.tw>)
- ✓ Open Data (<https://data.gov.tw>)



Broadcast through Media

公視 我們的島 our island



白朝金 | 水保署花蓮分署副分署長

#花蓮地震《群震過後》之二 | 生活在崩塌下(公視我們的島 第1254集 2024-05-06)

整個集水區的這些崩塌裸露

自由時報 Liberty Times Net

即時 熱門 政治 軍武 社會 生活 健康 國際 地方 蒐奇 影音 財經 娛樂 汽車 體育 3C 評論 藝文 玩趣 食譜 地產 專區 TAIPEI TIMES 求職

首頁 > 生活

山坡地崩塌嚴重 花蓮現土石流危機

f x u



花蓮縣七腳川溪上游山壁崩塌情況嚴重，圖左（左）像蜘蛛又像蜈蚣。（記者游太郎攝）

2024/04/12 11:05

【記者游太郎／花蓮報導】0403強震後，花蓮山區山坡地出現大規模崩塌狀況，民眾擔心一旦下起豪大雨，包括七腳川溪、須美溪等上、中游將出現土石流危機，呼籲水保單位儘快啟動防治機制；花蓮縣政府表示，已要求各鄉鎮市公所儘速巡視、查報，將專報提報行政院公共工程會撥款整治。

403花蓮地震 應變措施

花蓮強震 防坡地災害緊急調降警戒基準

2024/4/8 08:38 (4/8 09:26 更新)



中央通訊社

更生新聞網 NEWS

花蓮新聞 花蓮政治 影音新聞 台東新聞 活動看板 國內新聞 人事求職

凱米颱風影響臺灣 農村水保署呼籲山區民眾加強戒備 鎖定秀林鄉為重點關注地

2024-07-23 4:56 下午

記者田俊浩／報導

隨凱米颱風影響臺灣，農村水保署二十三日表示，花蓮縣處於0403大地震過後，致災風險增加，更需注意；已鎖定秀林鄉為重點關注地，包含當地的和仁部落、三棧南溪上下游及鄰近部落，都是風險較高的地方，為此已先進行河道疏通，但是颱風天下大雨土砂量仍大，需嚴密監控，依據警戒資訊請地方政府執行疏散。



自由時報 Liberty Times Net

即時 熱門 政治 軍武 社會 生活 健康 國際 地方 蒐奇 影音 財經 娛樂 汽車 體育 3C 評論 藝文 玩趣 食譜 地產 專區 TAIPEI TIMES 求職



花蓮強震，山區土石鬆動，農村水保署評估後緊急調降花蓮市、秀林鄉、吉安鄉及靜浦鄉、南濱鄉等5鄉鎮市的土石流警戒基準，並啟動衛星影像監控，圖為太魯閣遊客中心前錦文橋一帶河床。（資料照，記者王錦慶攝）

2024/04/08 10:13

新聞網

因應0403大震後汛期 農業部啟動先期治山防災整備

工商時報 陳懿芬 2024年5月23日



花蓮縣秀林鄉木瓜溪上游堰塞湖，圖／農業部提供

5

Visit Local Government

- ✓ Ask the chief to update the evacuation plan.
- ✓ Remind the chief to enhance disaster mitigation and propaganda after the quake.
- ✓ Explains to the residents about the sediment sensitive area risks after the quake and to cooperate when evacuate.



	1	2	3	4	5	6	7	8	9	10	11	12
Visit Date	4/22	4/22	4/23	4/26	4/23	4/29	4/29	5/7	5/27	5/28	6/6	6/6
Office Visited	Hualien Township	Agr. Dept, Hualien County	Xiulin Twp.	Jian Twp.	Yuli Twp.	Shoufeng Twp.	Fuli Twp.	Hualien County Magistrate	Chongde Vil. Head	Jingmei Vil. Head	Yuemei Vil. Head	Fengxin, Nanping Vil. Head

6

Governance Platform Monthly

Member



9th River Man.
Branch



Hualien
Branch,
ARDSWC



Hualien Branch,
Forestry Agency



Hualien Irrigation
Agency



Hualien
County Gov.



Taiwan
Water Co.

Purpose

- ✓ Hold monthly meeting to enhance **cross agency mitigation.**

Goal

- ✓ **Information exchange**, resource sharing in Hualien region.



7

Regional Joint Inspection

- ✓ 6/24, 6/27, 7/8, 8/9, 8/29 held joint inspections with **Railway Co.**
- ✓ 5/3, 8/2, 8/12 held joint inspections with **Highway Bureau** along Route 9.
- ✓ 7/1, 7/31 held joint inspections with local **Township Gov.**
- ✓ 8/12 **Ministry of Transportation** held discussion meeting regarding the long term mitigation along the heavily stricken corridor.



8

Emergency Engineering Treatment (Hualien D)

Risk
Treatment

- ✓ New landslides in torrent catchment.
- ✓ Pre-event dredging in bottleneck sector.
- ✓ Temporary sediment trapping device installed in late May.
- ✓ Community table top exercise, CCTV installation.
- ✓ Heavy machinery stand by during typhoon event.

Type B

Dredging

Soldier Beams Trapping Sediment (May)



04

2024 Typhoon Events

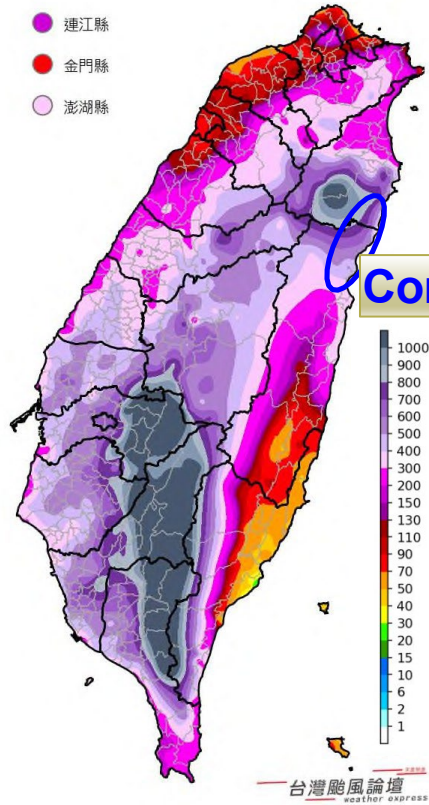


Typhoon Gaemi

Rainfall 7/24~7/26

Accu. **550** mm

Max. **87** mm/hr



161K Route 9 DF



Railway Bridge Destroyed



Route 9 Buried by DF



Rail Track Buried by DF



7/24 17:00

Accu. **307.5** mm

Max. **86.5** mm/hr

Hualien DF174

Debris flow Event

1st: 16:58

2nd: 17:03

3rd: 17:13

4th: 17:29



CCTV Recorded DF Event

Typhoon Gaemi

Source: EBC News



- Sediment $V=21,500\text{m}^3$
- Railway closed for 10 days



Source: EBC News



Hualien DF173

Typhoon Gaemi

- ✓ 7/23 Typhoon Warning,
7/23 18:30 Yellow Alert,
7/24 18:30 Red Alert.
- ✓ 7/24 15:00 residents
evacuated.
- ✓ Heavy machinery stand
by and cleaned after DF
event.

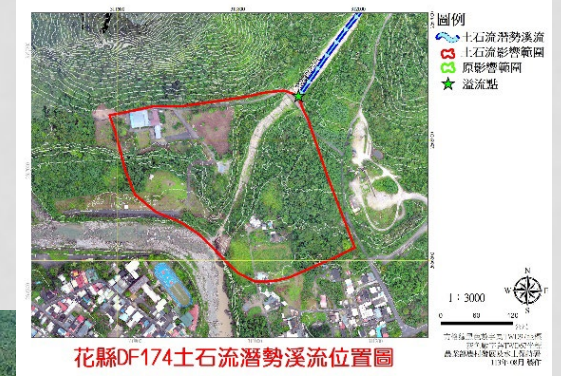


7/24 17:00
Hourly 80 mm/hr
Accu. 250 mm



Typhoon Gaemi

In the **4** newly added debris flow torrents in the EQ area,
sediment disasters were recorded in **3** during Typhoon Gaemi.



Typhoon Gaemi

■ **28** Debris Flow Red Alert

■ **77** Debris Flow Yellow Alert

■ **2** Large Scale Landslide Yellow Alert

■ **54** Cell Broadcasting

■ **3,296** evacuated

■ **No fatalities!**



警訊通知

[土石流及大規模崩塌警戒]花蓮縣吉安鄉太昌村，已發布土石流黃色警戒，請提高警覺。農業部關心您，0800_246246。

[Warning]Debris flow in this area.

<https://246.ardswc.gov.tw/?CTV=U11003>

Debris Flow Warning



警訊通知

[土石流及大規模崩塌警戒]花蓮縣秀林鄉崇德村共5處(花縣DF173)，1小時累積雨量已達13mm、3小時累積雨量已達132mm、24小時累積雨量已達274mm，請提高警覺，農業部關心您。[Warning]Rainfall reached the warning level. ARDSWC.

TEL:0800_246_246

Heavy Rainfall Warning

	Township	Debris Flow	Large Scale Landslide	People Evacuated
1	Xiulin	19	-	916
2	Shoufeng	9	-	25
	Red Alert	28	0	
3	Xiulin	13	-	187
4	Shoufeng	11	1	79
5	Jian	7	-	258
6	Hualien City	3	-	20
7	Fenglin	9	-	83
8	Guangfu	18	1	166
9	Fonggbin	16	-	49
	Yellow Alert	77	2	
Up to 20:00 Jul. 25				

05

Conclusions & Ongoing Challenges



CONCLUSIONS

- ▶ After mega earthquake **new types** and larger scale of sediment disaster became new challenges in eastern Taiwan.
- ▶ An example of **risk governance** and **management** of sediment disaster in eastern Taiwan during 2024 typhoon season was given.
- ▶ Applying **transdisciplinary approach** to tackle complex disaster type in future extreme climate scenario is necessary.

ONGOING CHALLENGES



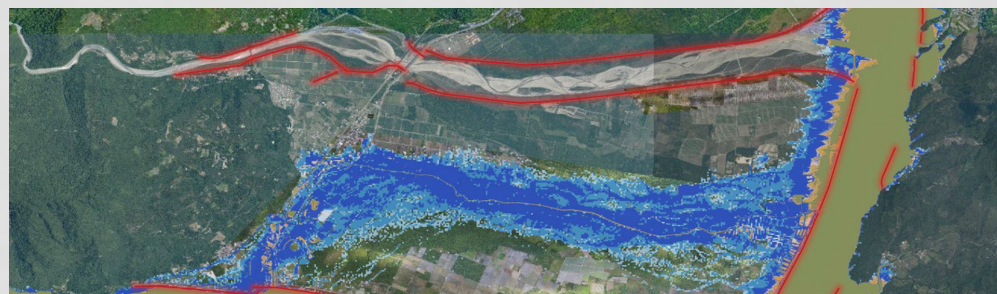
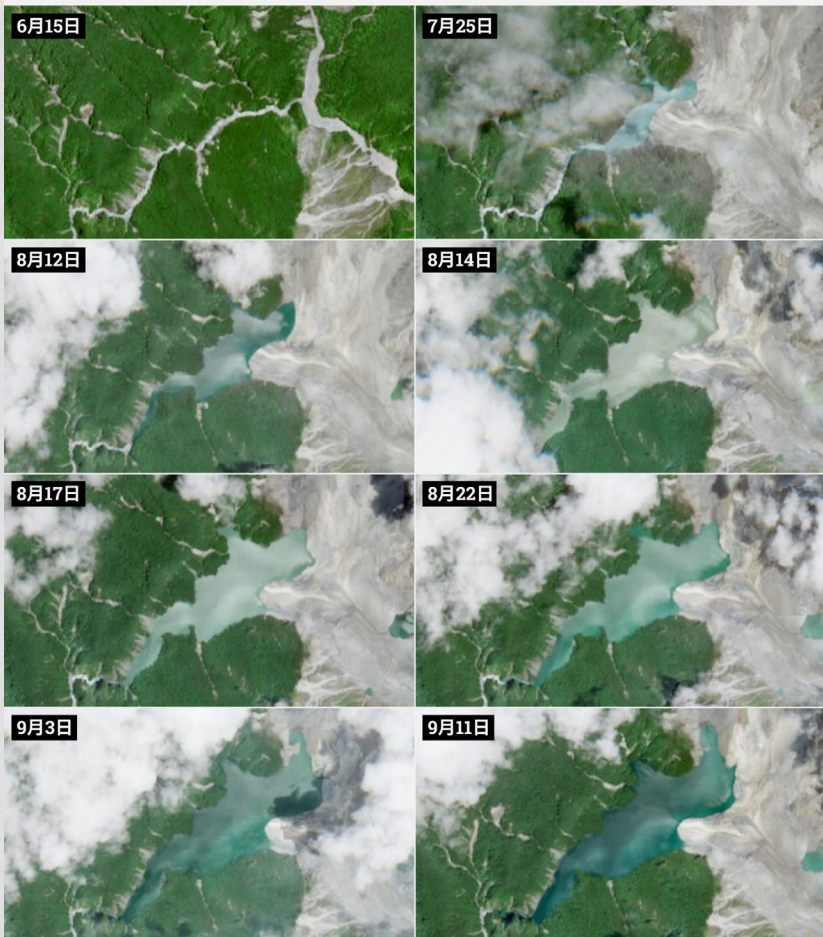
Dam



ONGOING CHALLENGES

Monitoring

馬太鞍溪堰塞湖變化



COS-Flow淹水範圍

Simulation

Evacuation

Public Meeting



因為不能再待在這邊了

我們都會在群組裡面

Type C

THANK

YOU



Ting-Chi TSAO 曹鼎志  **財團法人 中興工程顧問社**
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