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Natural Disaster and Countermeasure in Taiwan

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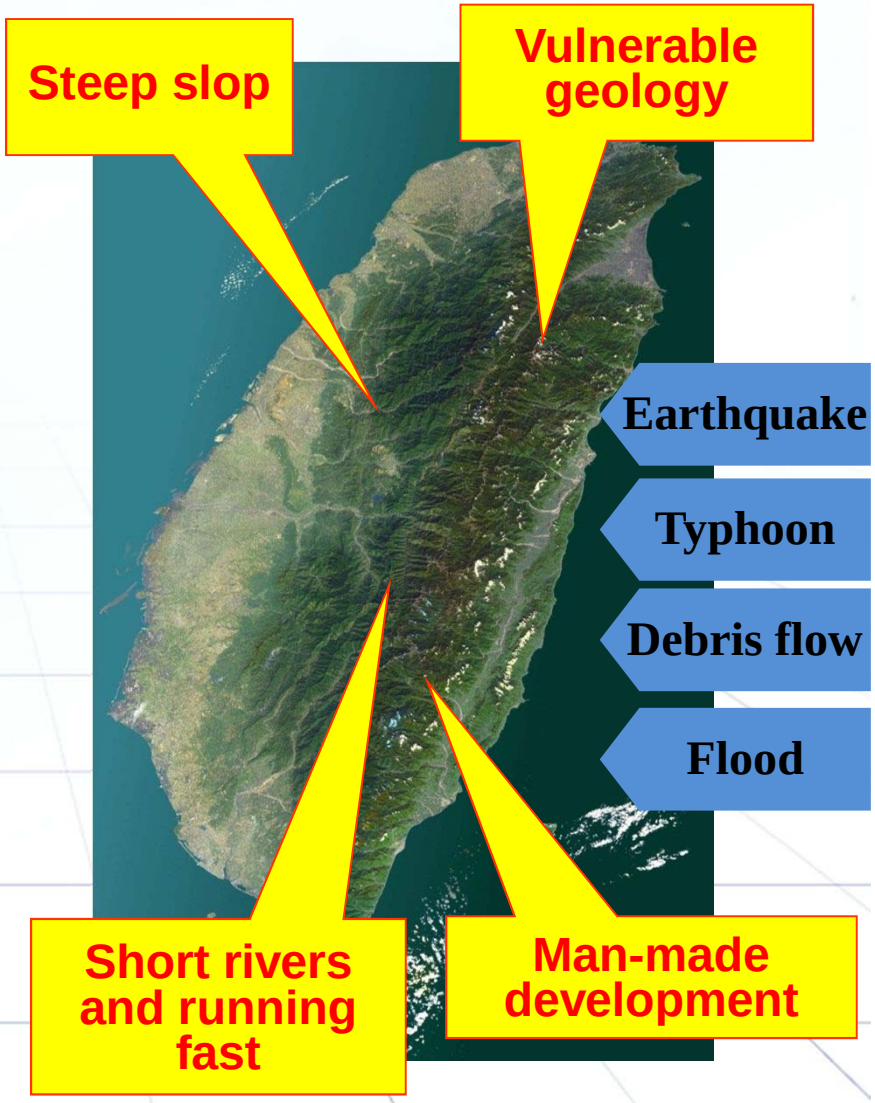
CONTENT

1. Environment of natural disaster

- Total area : 36,000km^2
  Population: 23 million
- Belong to subtropical climate, average annual rainfall is about 2,500mm, 70% from May to October.
- 3/4 lands of Taiwan are mountains. High population density and over-development.
- Recently, there are higher frequency of heavy rains in Japan and Taiwan due to global warming.

Environment characteristic of Taiwan



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2. Characteristic of natural disaster

2-1 Typhoon and Heavy rain

- ► Rivers of steep slope(Upper stream 1/100、Downstream 1/500～1000）.
- ► Weak geology and collapses easily. A lot of mud from flood brings debris flow.

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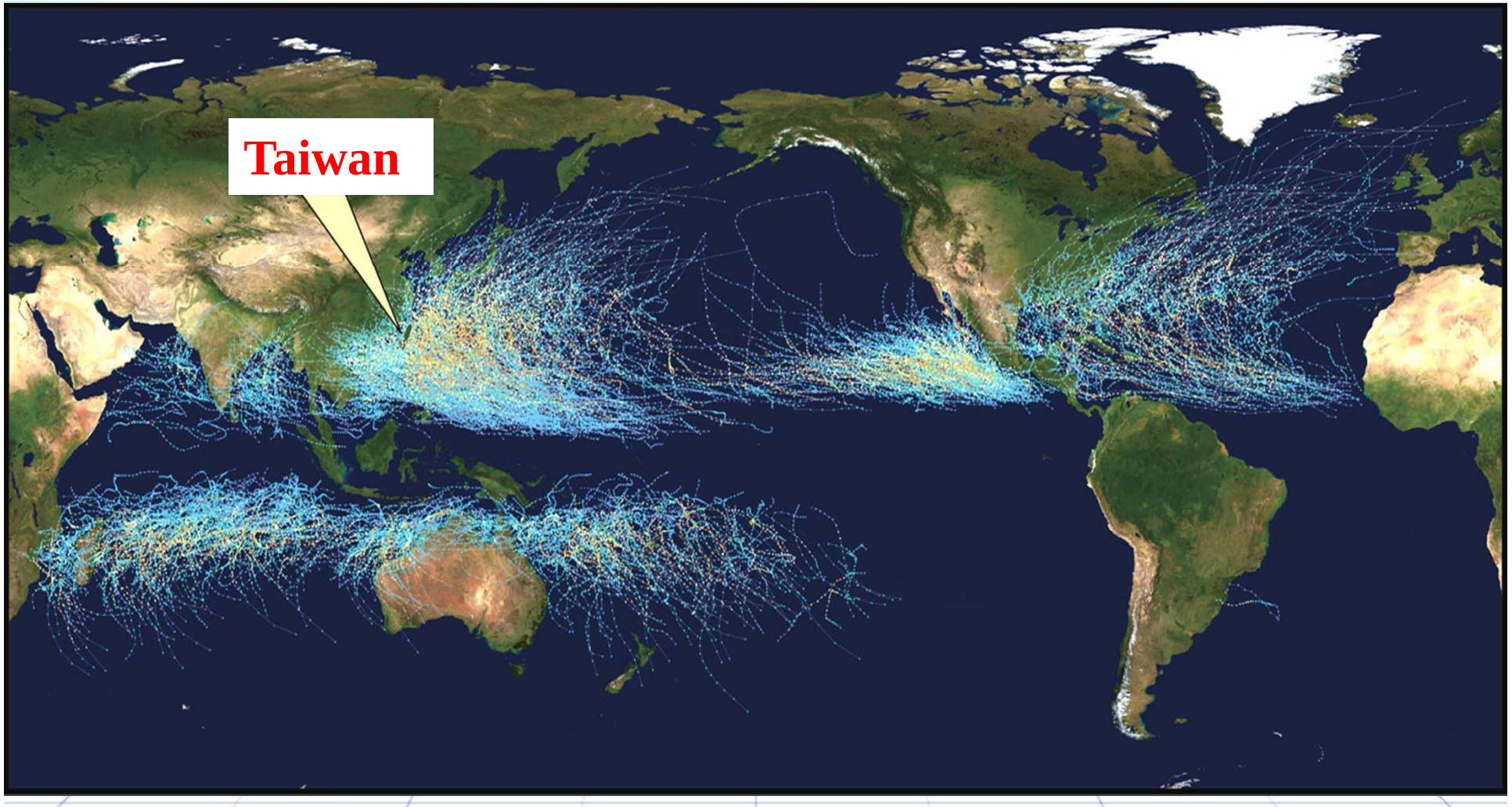
Map of Typhoon Route, 1985~2005



- Taiwan and Okinawa suffered the most typhoons

Ref：NASA

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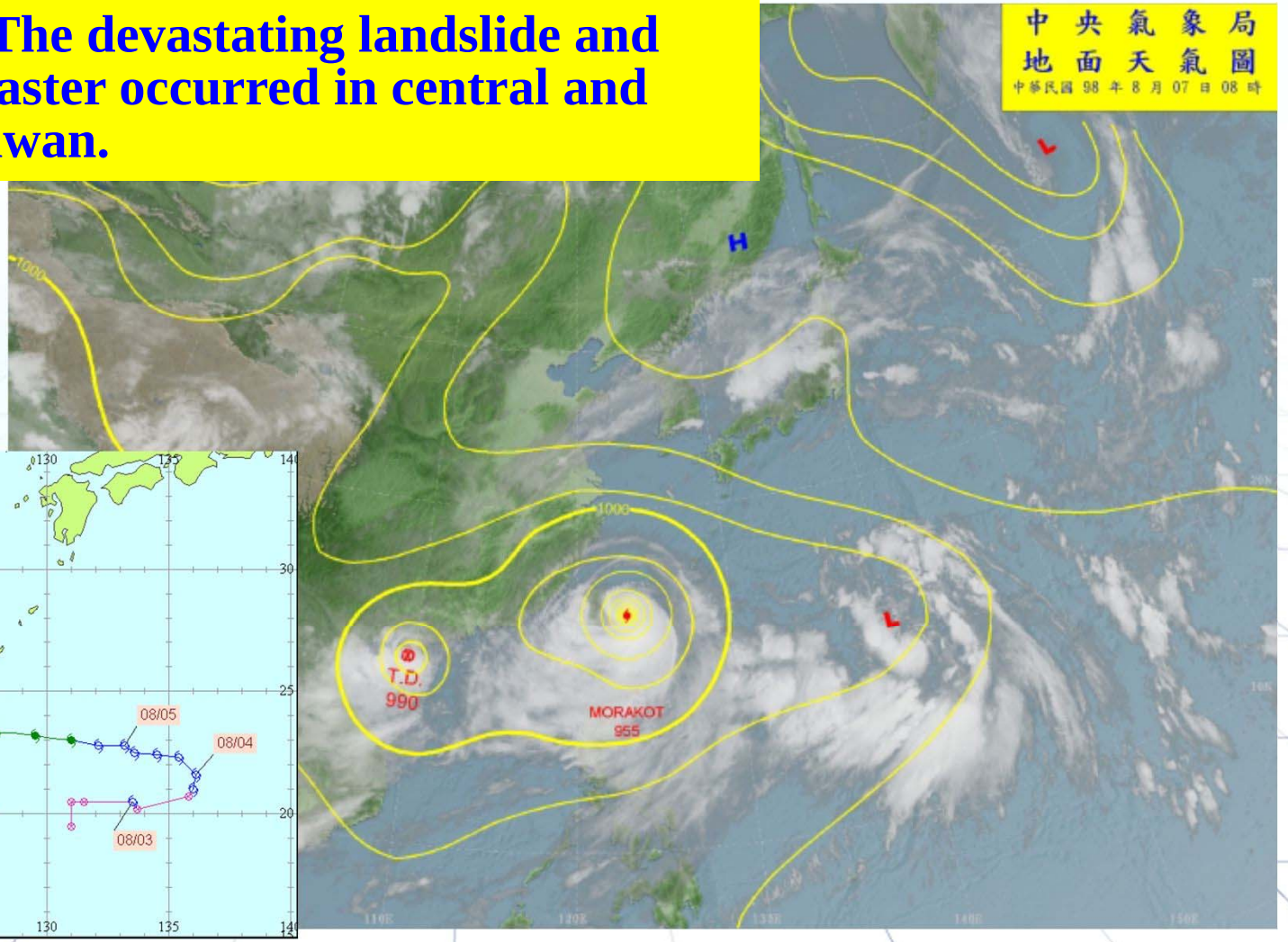
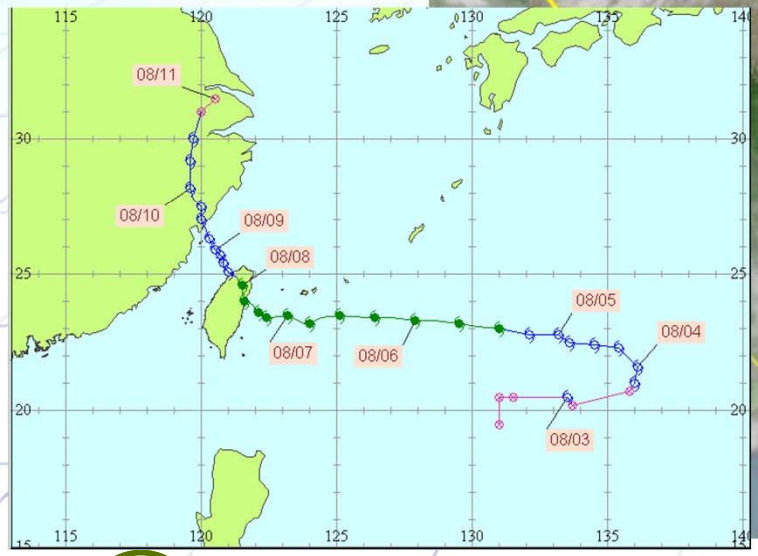
Typhoon Morakot caused the most severe damage to Taiwan in 2009

► **Heavy rain for 96 hours from 08/06/2009 ~ 08/10/2009. The devastating landslide and the flood disaster occurred in central and southern Taiwan.**





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Typhoon Morakot caused the most severe damage to Taiwan in 2009

Damaged Bridges Summary (8/21/2009)

	Provincial Highway	County Roadway	Country Roadway	Total
Collapsed Bridges	41	3	17	61
Disconnected Bridges	5	0	0	5
Subtotal	46	3	17	66

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Isolated Area Damaged Condition

- There are total 8 damaged isolated areas, one of them has been connected for traffic , the rest 7 isolated areas are still under co nstruction to open the traffic.

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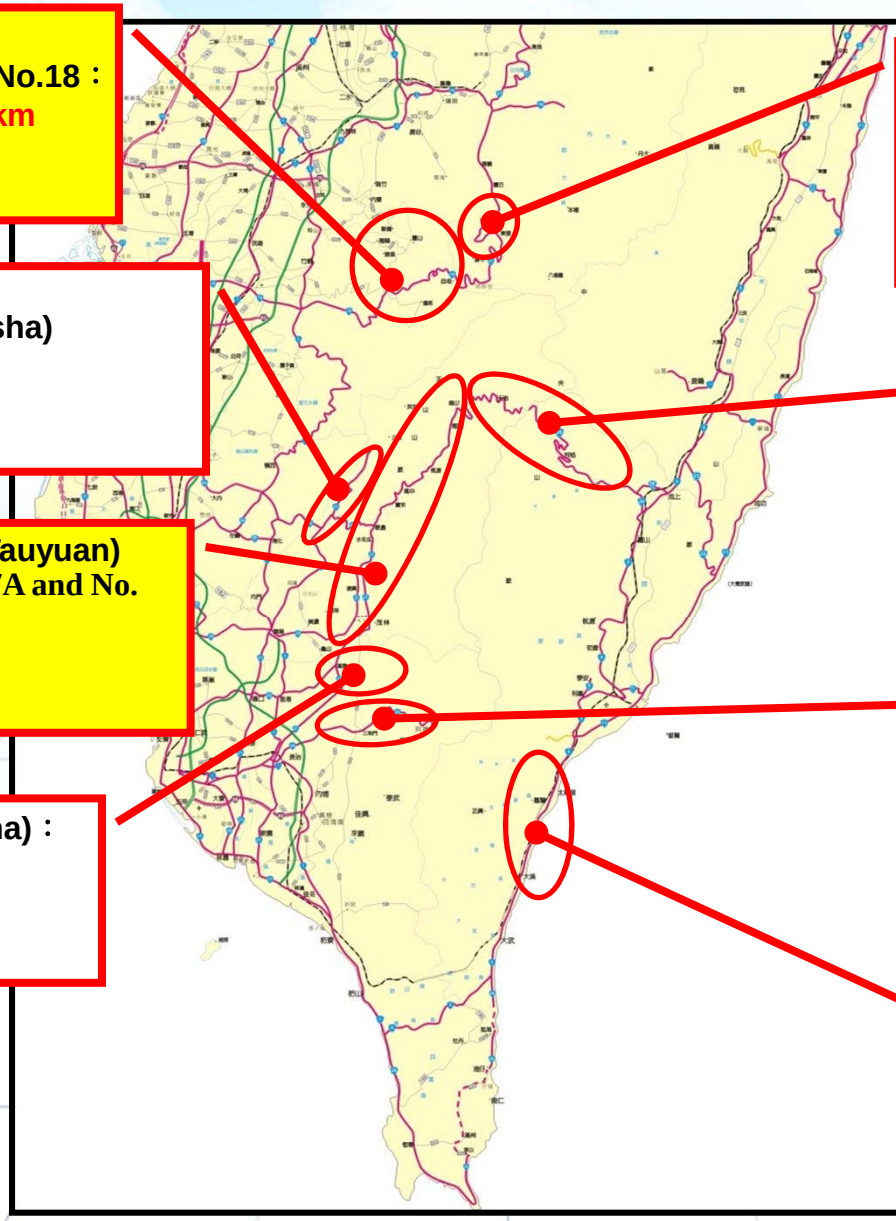
Major Damaged Areas Traffic Condition



Chiayi (Alishan)
Provincial Highway No.18：
Disconnected 126.0km
Open 61.8km
Progress 49.04%

Kaohsiung
(Chishan~Jaishian~Namasha)
Provincial Highway No.12：
Disconnected 65.0km
Open 42.1km
Progress 64.8%

Kaohsiung (Liouguei~Tauyuan)
Provincial Highway No.27A and No. 20：
Disconnected 85.0km
Open 45.7km
Progress 53.7%

Kaohsiung (Maolin~Dona)：
Disconnected 16.5km,
Open 2.5km ,
Progress 15.1%

Circled areas are the isolated areas that need to connect for traffic

Nantou
(Tongfu~Tongpu~Tatachia)
Provincial Highway No.21 and No.18：
Disconnected 66.0km
Open 22.5km
Progress 34.1%

Taitung
(Tauyuan~Lidau~Wulu)
Provincial Highway No.20：
Disconnected 76.3km
Open 26.5km
Progress 34.7%

Pingdong (Sandimen~Wutai)
Provincial Highway No.24：
Disconnected 20.5km
Open 10.1km
Progress 49.3%

Taitung (Taimali~Fonggong)
Provincial Highway No.20：
Disconnected 70.3km
Open 70.3km
Progress 100%

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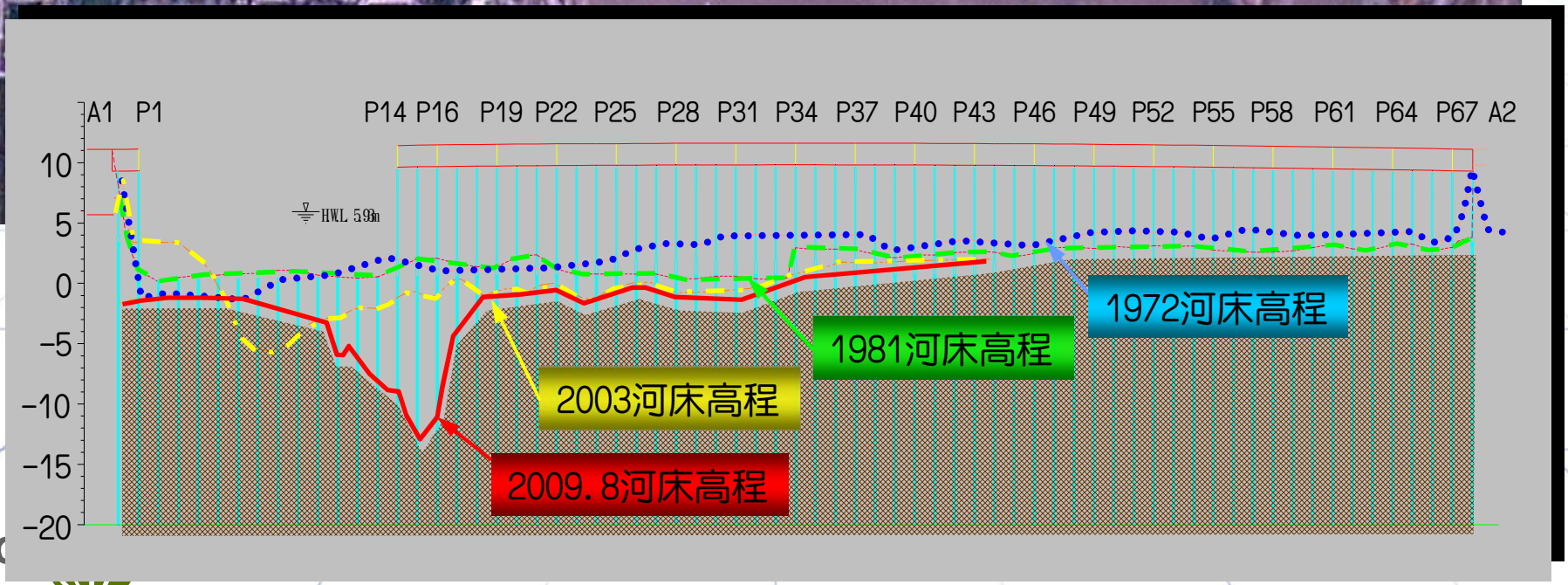
Road, Bridge

Scouring and collapsed of Swan-Yuan bridge caused by Morakot typhoon



Road, Bridge

Reconstruction of Swan-Yuan bridge after Morakot

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Collapsed Bridge Rehabilitation Strategy

- Large span length, less piers for rebuilt and new -built bridge, scenical bridge integrated with local landscape
- Pier location avoid deep river channel
- Stream-flow pier shape
- Increase the anti-flood ability for structure
- For unstable river, increase the pile length and a llowable free standing length for scouring

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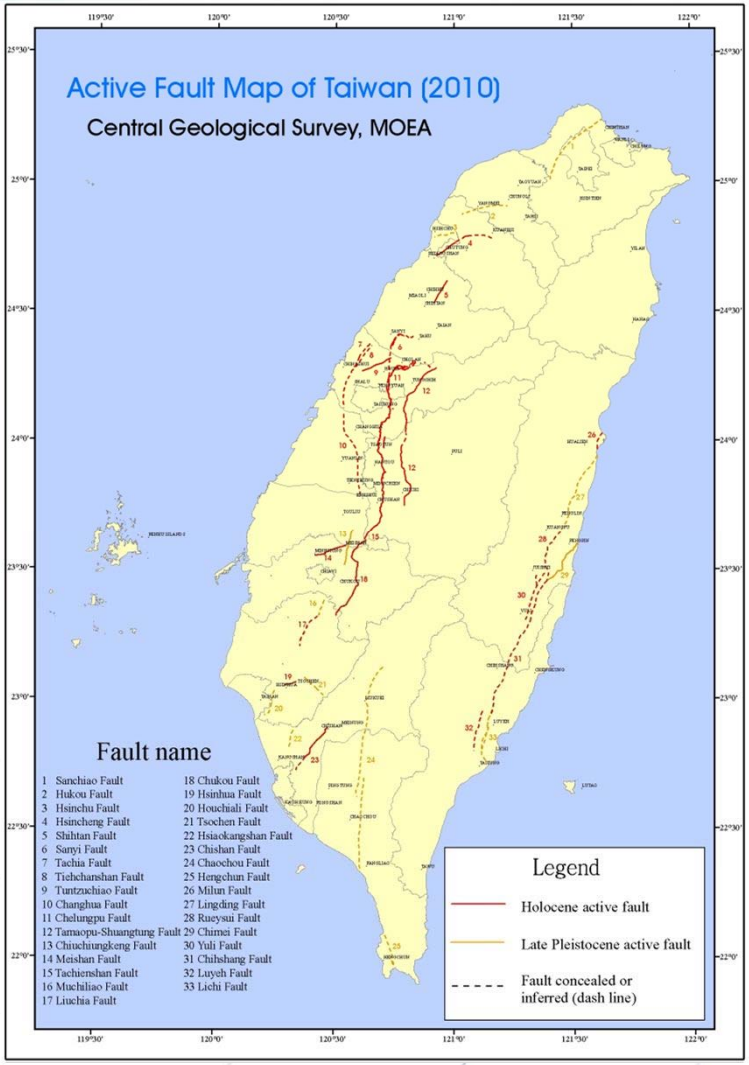
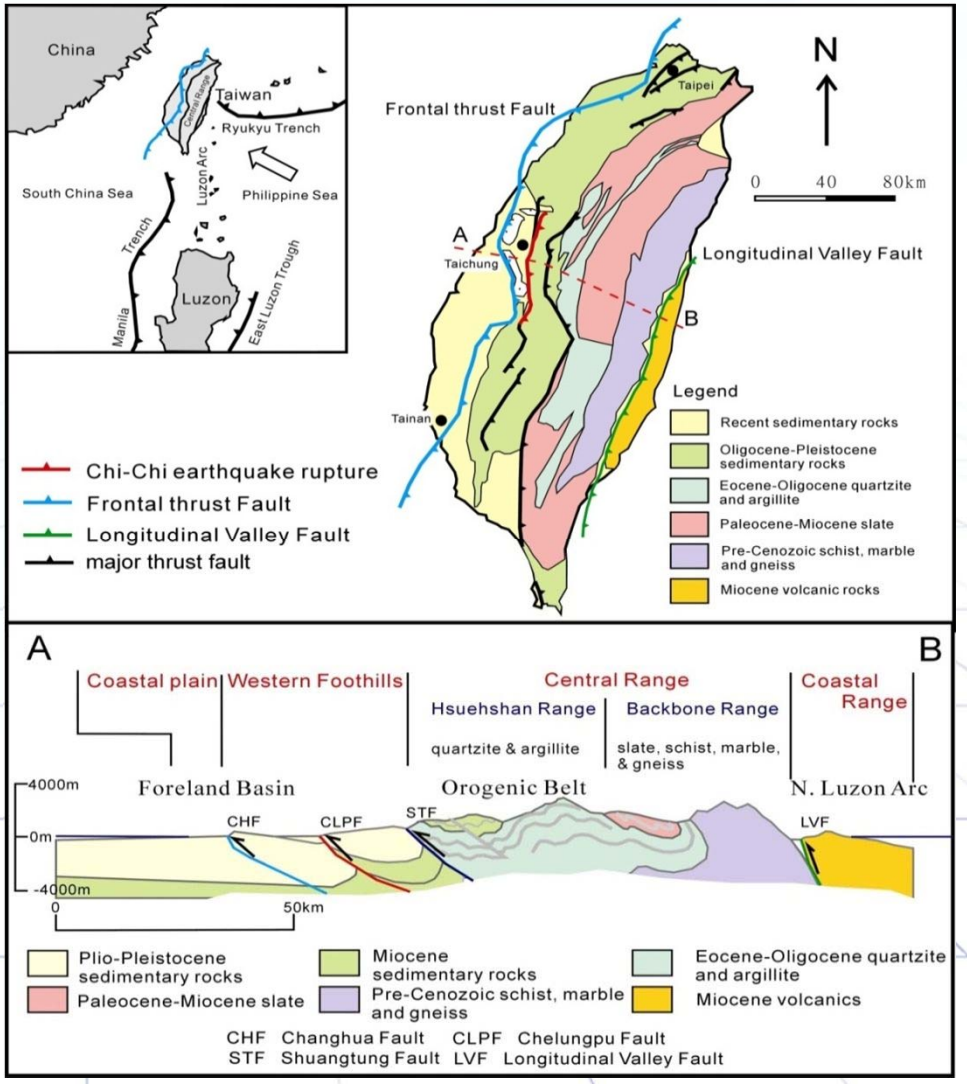
2-2 Earthquake

► Active fault map for Taiwan (Ref: CENTRAL GEOLOGICAL SURVEY, MOEA)





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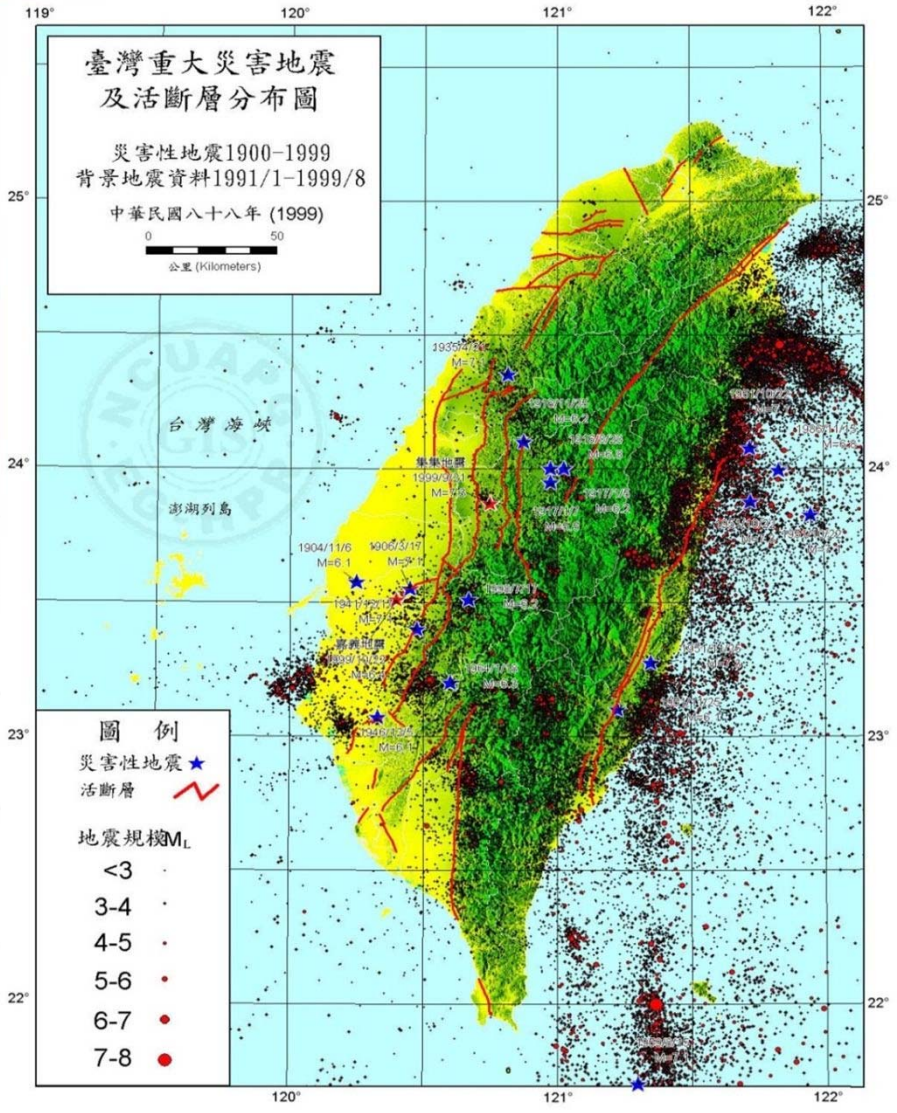
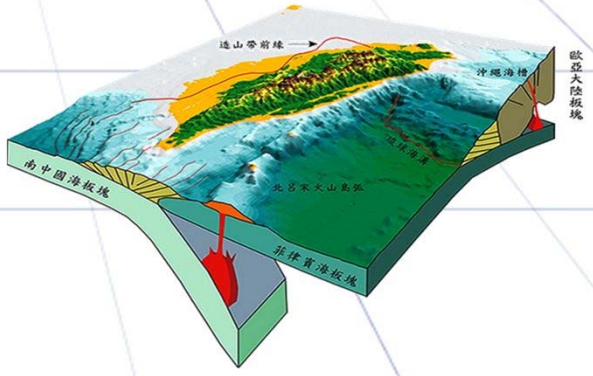
經濟部中央地質調查所
CENTRAL GEOLOGICAL SURVEY, MOEA

Fault layout and earthquake illustration

► Many earthquakes from active fault of Philippine Sea plate slipping into the Eurasian plate



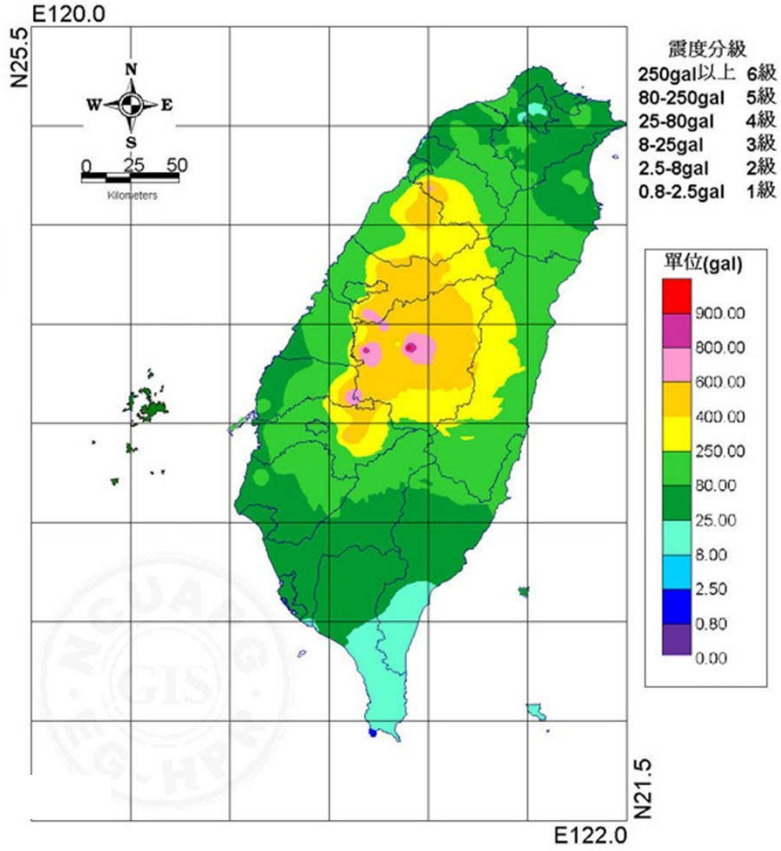
- 1906年3月梅山地震(M=7.1)
- 1935年4月新竹台中烈震(M=7.1)
- 1941年12月中埔地震(M=7.1)
- 1964年1月台南白河地震(M=6.3)
- 1972年4月花蓮瑞穗地震(M=6.9)
- 1986年11月花蓮地震(M=6.8)
- 1990年12月花蓮地震(M=6.7)
- 1998年7月嘉義瑞里地震(M=6.2)
- 1999年9月集集大地震(M=7.3)
- 2002年3月331地震(M=6.8)
- 2010年3月高雄甲仙地震(M=6.4)



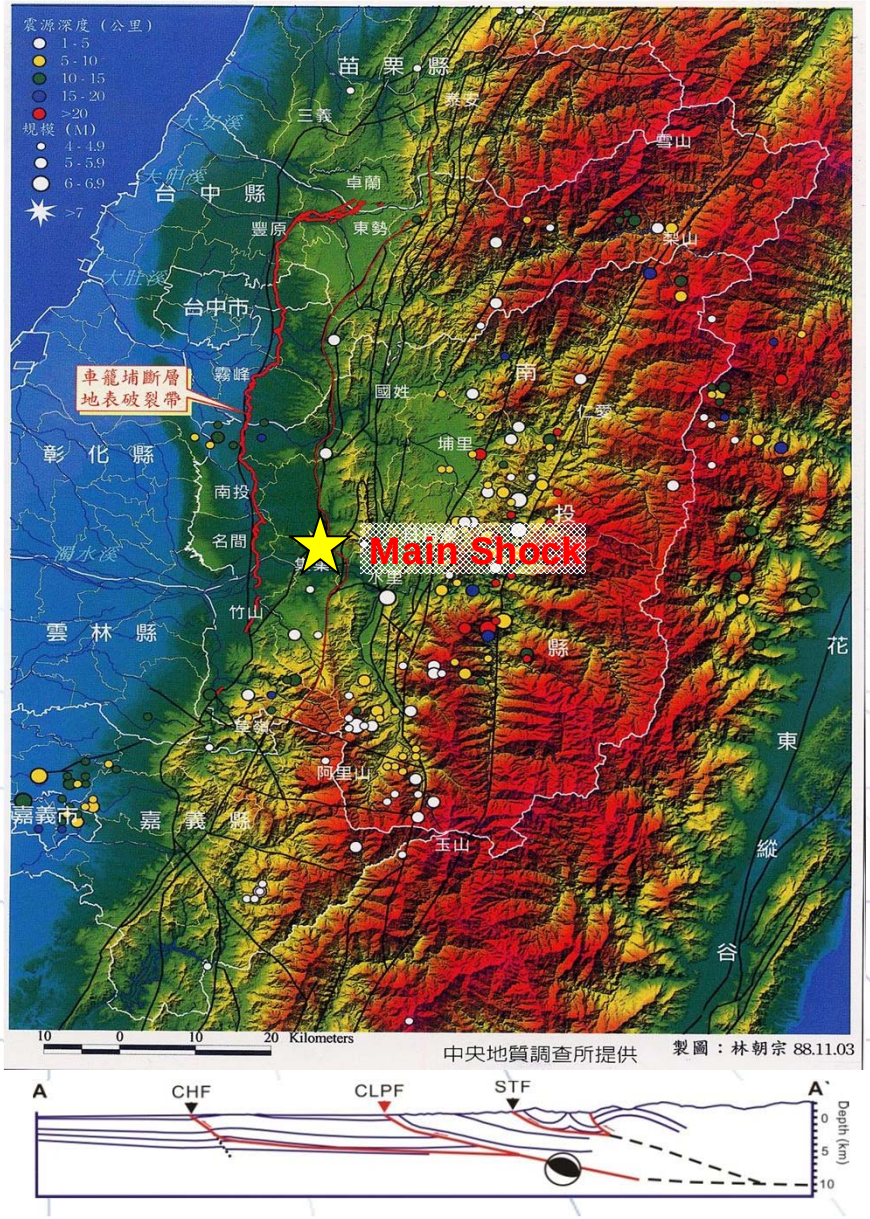
Chi-Chi Earthquake

發震時間：	88年 9月21日 1時47分15.9秒
震央位置：	北緯23.85˚ 、東經120.82˚
震源深度：	8.0 公里
芮氏規模：	7.3

921集集地震台灣地區各地震度圖

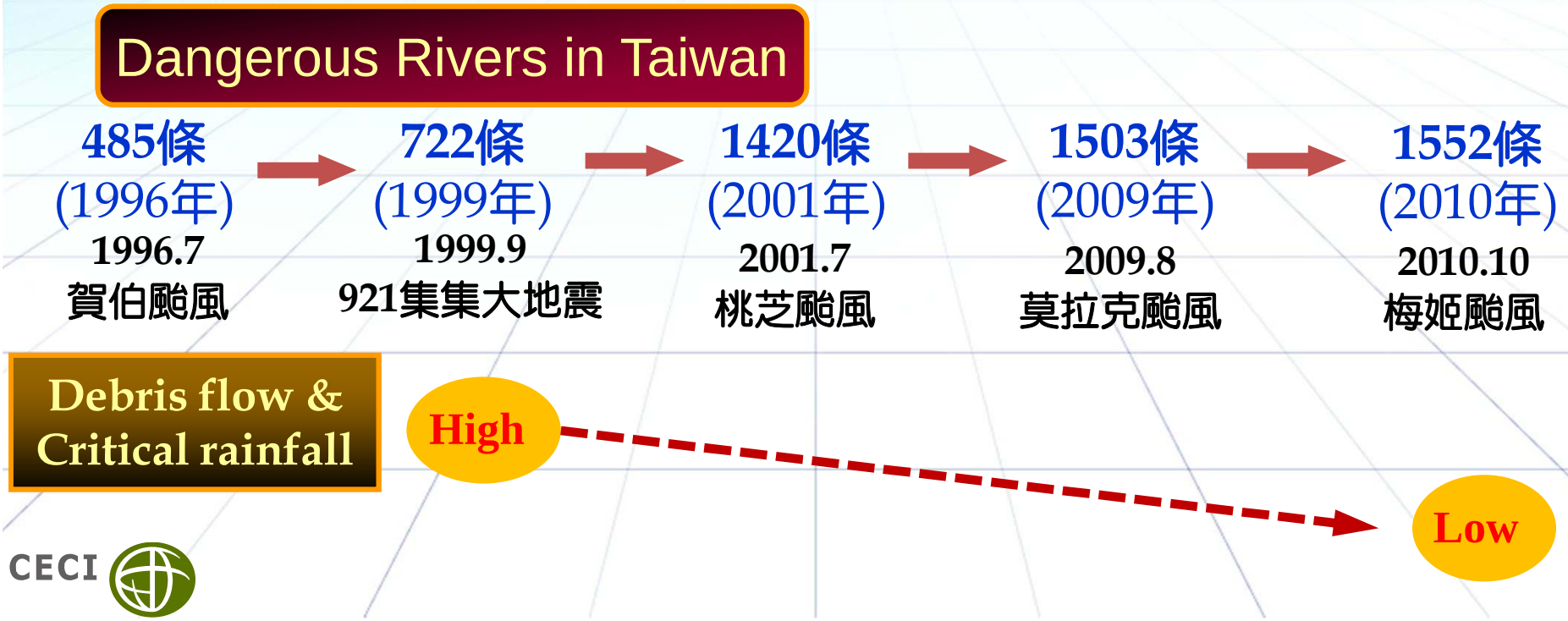


► **Seismic intensity figure of Taiwan Chi-Chi earthquake(M= 7.3)**



2-3 Debris Flow

- **Investigation in 1996, 485 rivers have high potential of debris flow, and it became 722 rivers after Chi-Chi earthquake in 1999. And there are 1,503 after Morakot typhoon in 2009.**
- **Sediment mass leave after earthquakes and typhoons, debris flow occurs when rainfall of more than 40mm or 150mm**



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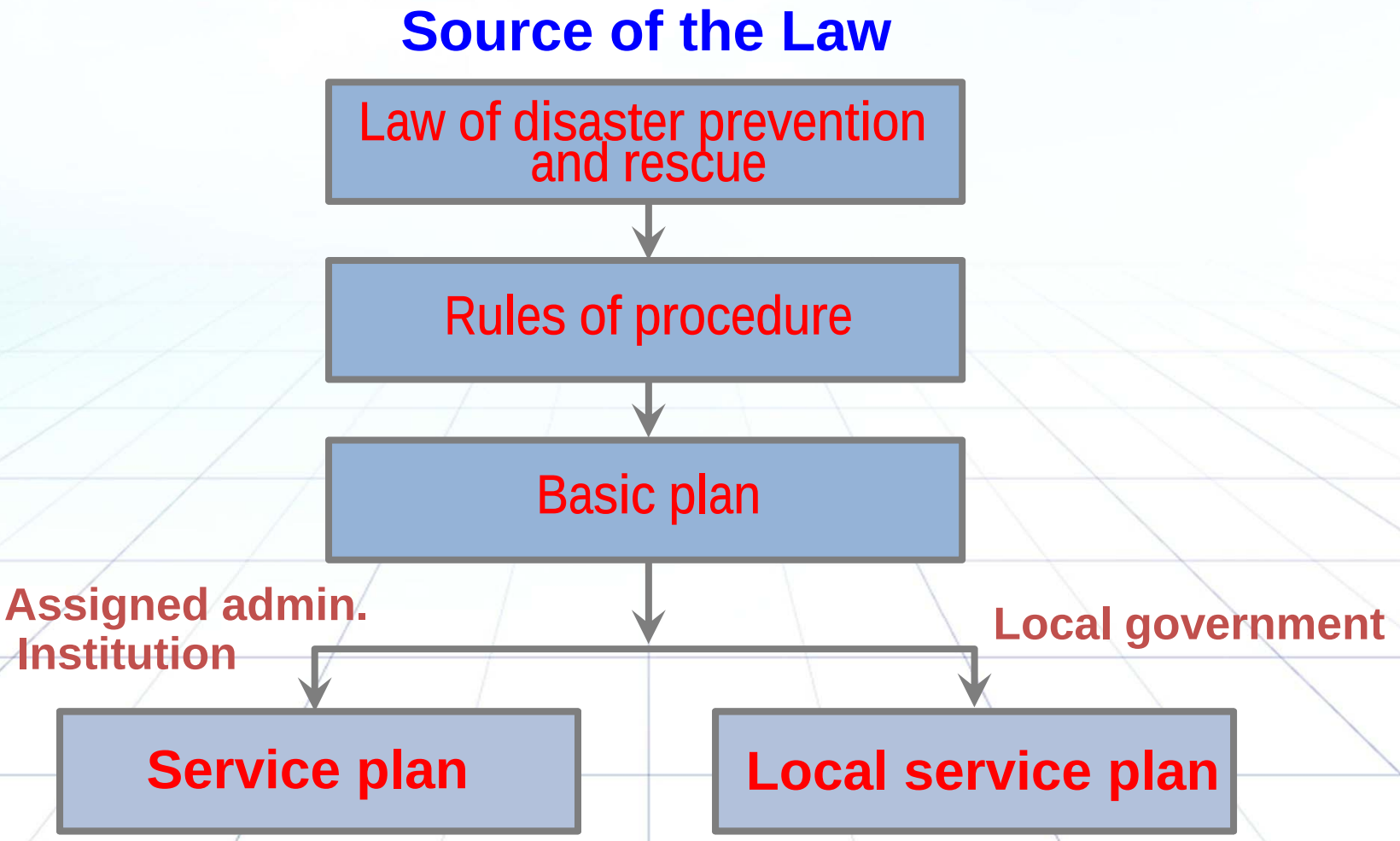
3.Disaster Prevention Policy

Disaster management system of Taiwan



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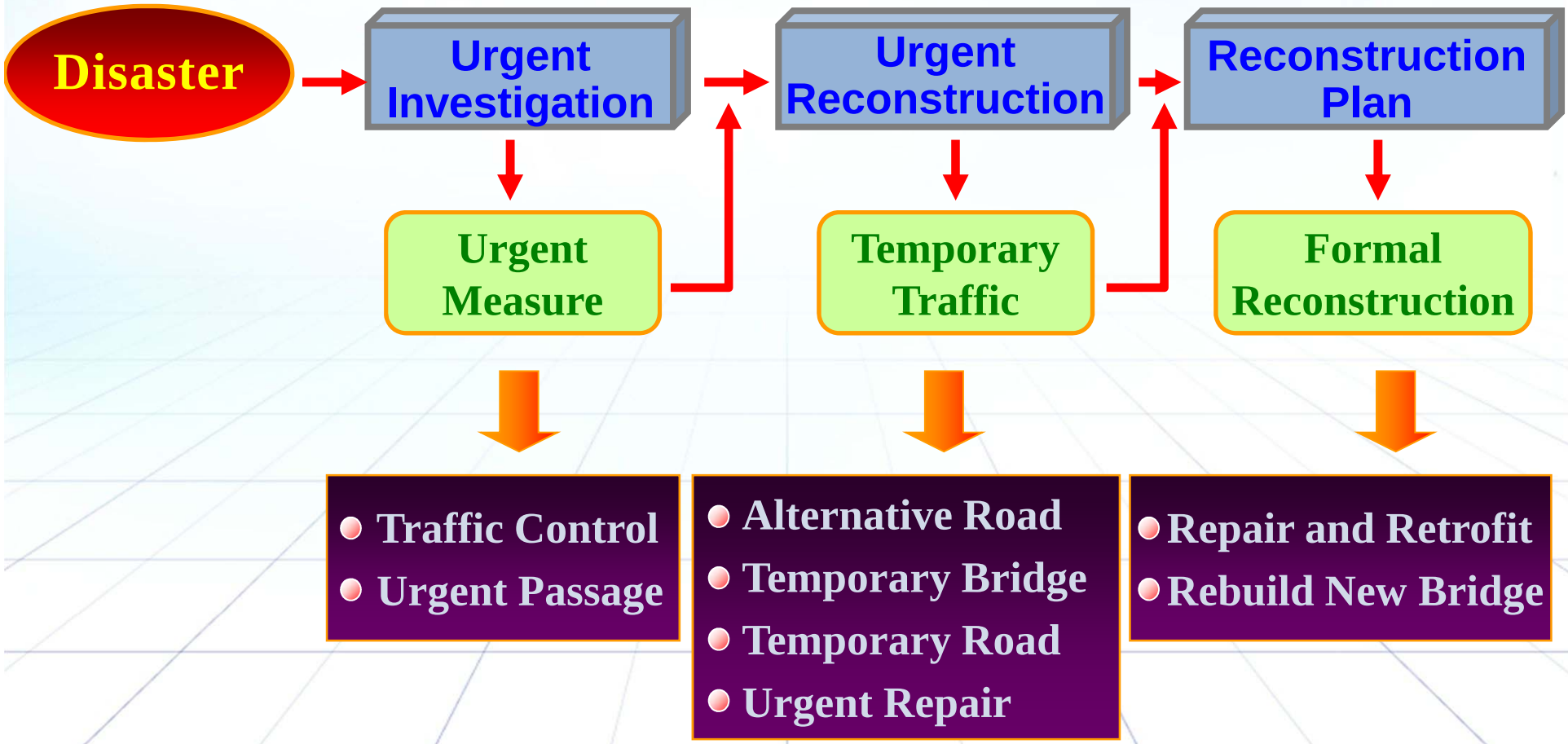
4. Bridge Reconstruction Procedure After Disaster



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E-Jiang Bridge's temporary traffic after Chi-Chi (921) earthquake

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The principle of Bridge Reconstruction for Flood Damage

- Up-lifting bridge elevation
- Increasing bridge length
- Enlarging span
- Deep foundation
- Consideration of impact force
- Anti-collision devices

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The principles of bridge reconstruction for debris flow damage

- Debris flow damage happened on mountain area
- Debris flow will occur at the same place, Can not reconstruct at same location
- **The principles of bridge reconstruction for debris flow damage:**
  - **Relocate bridge**
  - **Extend bridge length**
  - **Enlarge span**
  - **Increase bridge clearance**
  - **Design the impact force**
  - **anti-collision device**

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Conclusion

- Due to the special topographical and geological conditions, there are many natural disasters in Taiwan. So, mountain, river, bridge and road should be considered together for disaster prevention.
- For the global climate change and extreme weather condition:
  - Design standard and safety criteria shall be rechecked.
  - Establish a low carbon consuming society without global resource extermination.
  - Build a risk management for reduction of disaster.
- Human beings should make friends with natural environment to avoid tragedy.

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