



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

TCCIP 臺灣氣候變遷推估與資訊平台  
Taiwan Climate Changes Projection & Information Platform

# Flood Impact Assessment of Climate Change on Zhengwen River basin

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# TCCIP Project Structure



Weather information collection

CMIP5 data 、 High-resolution GCM

**Team1**

Observation and model  
output analysis

Model outputs analysis

**Team2**

Downscaled projection  
production

Needs for  
phenomenon analysis

Data analysis and  
correction in Taiwan area

Downscaled data

**Team3**

- Researches on data applications for users
- Uncertainty analysis

Experiences and knowledge  
of application

Key knowledge and tools

**Team4**

Information service, communication, results  
promotion

- Observation data
- climate change trends
- Science technology

- Projection data
- Trends of climate change

# About Taiwan



- Area: 36,193 km<sup>2</sup>
- Population: 23 million
- Density: 644/km<sup>2</sup> (17<sup>th</sup>)
- GDP: 2,2000 US (39<sup>th</sup>)
- HDI: 0.89 (23<sup>rd</sup>)
- Developed country

(Wikipedia)



# Complex terrain

- Larger part of mountain area (70%)
- Short river, swift current, steep slopeland, alluvial plain



(East rift valley : Photo by Tourism Bureau, Taiwan)

# Long coastline



- Taiwan has a coastline of 1,566.3 km
- Coastal inundation, storm surge, erosion



(**Kenting** : Photo by Tourism Bureau, Taiwan)

# Highly urbanization

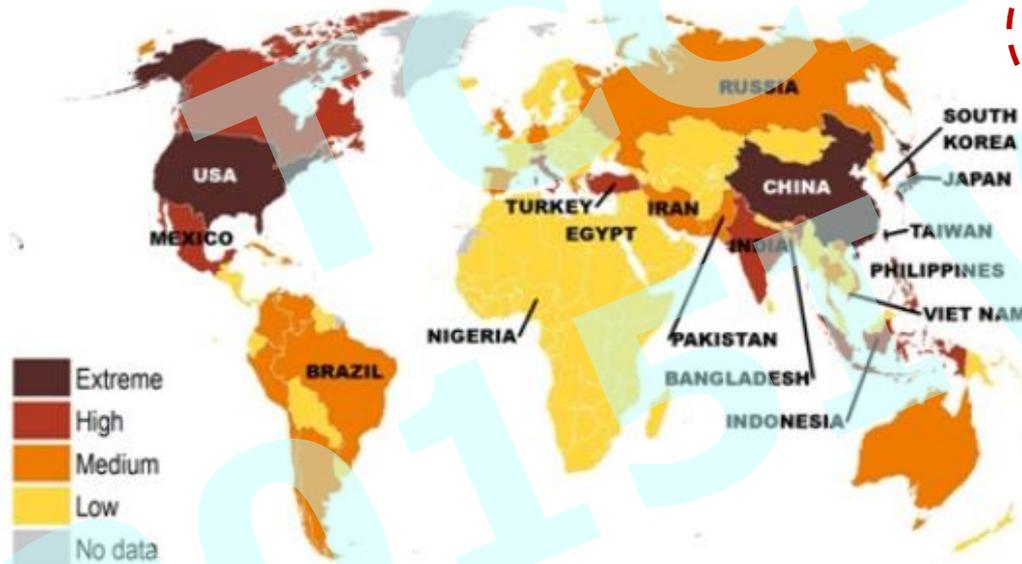
- Populations of 5 major cities are over 2 millions in Taiwan.



(**Taipei 101**: Photo by Tourism Bureau, Taiwan)

# Highly economic loss risk for natural disasters

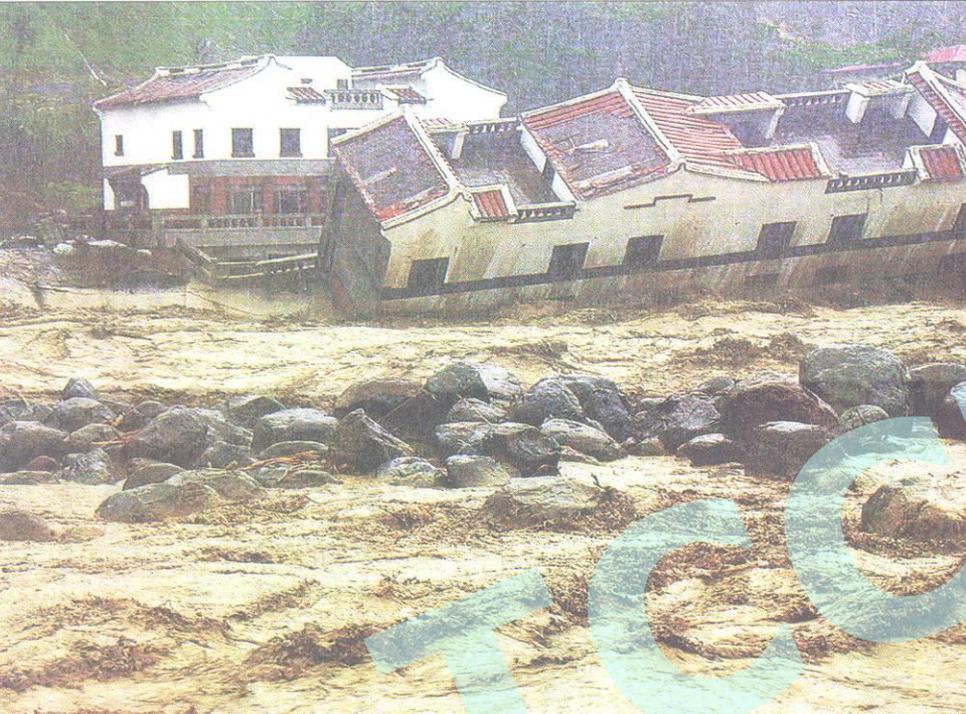
## Absolute Economic Exposure Index 2011



- **USA, Japan, China and Taiwan** have the greatest economic output exposed to natural hazards

- However, the emerging economies of **Mexico, India, Philippines, Turkey and Indonesia** also have significant economic output exposed to major natural hazards

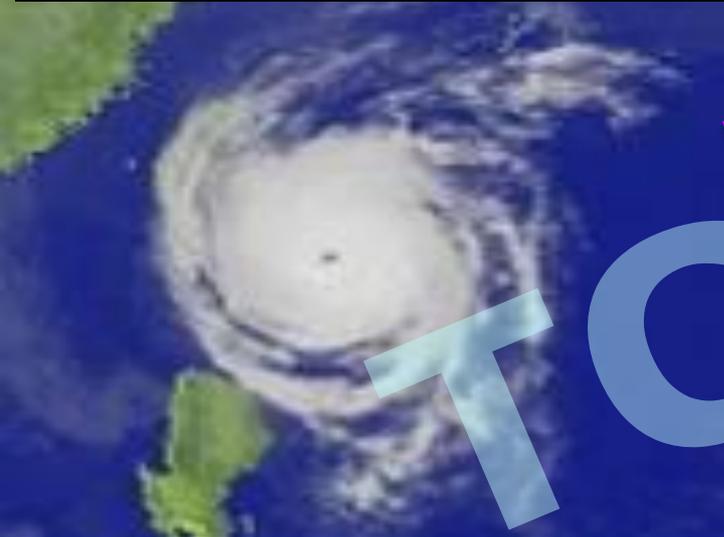
Despite significant economic growth, many of the emerging economies have yet to develop a resilience to the natural hazard risk they face



# 3 Major Climate/Weather Hazards in Taiwan



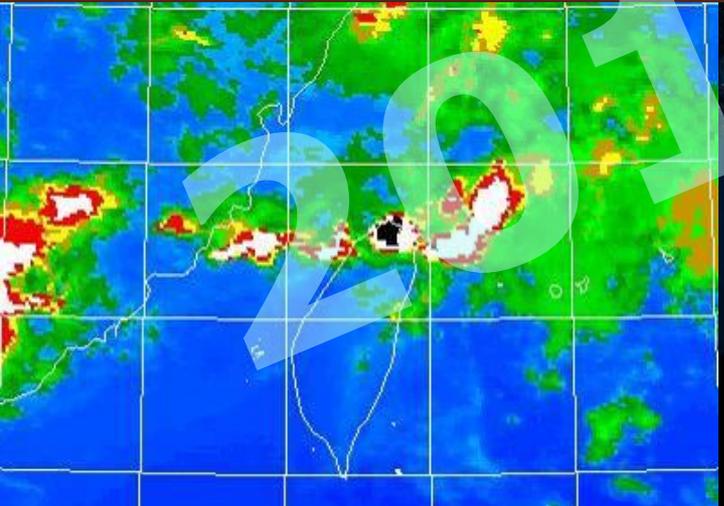
## Typhoon



## Seasonal monsoon

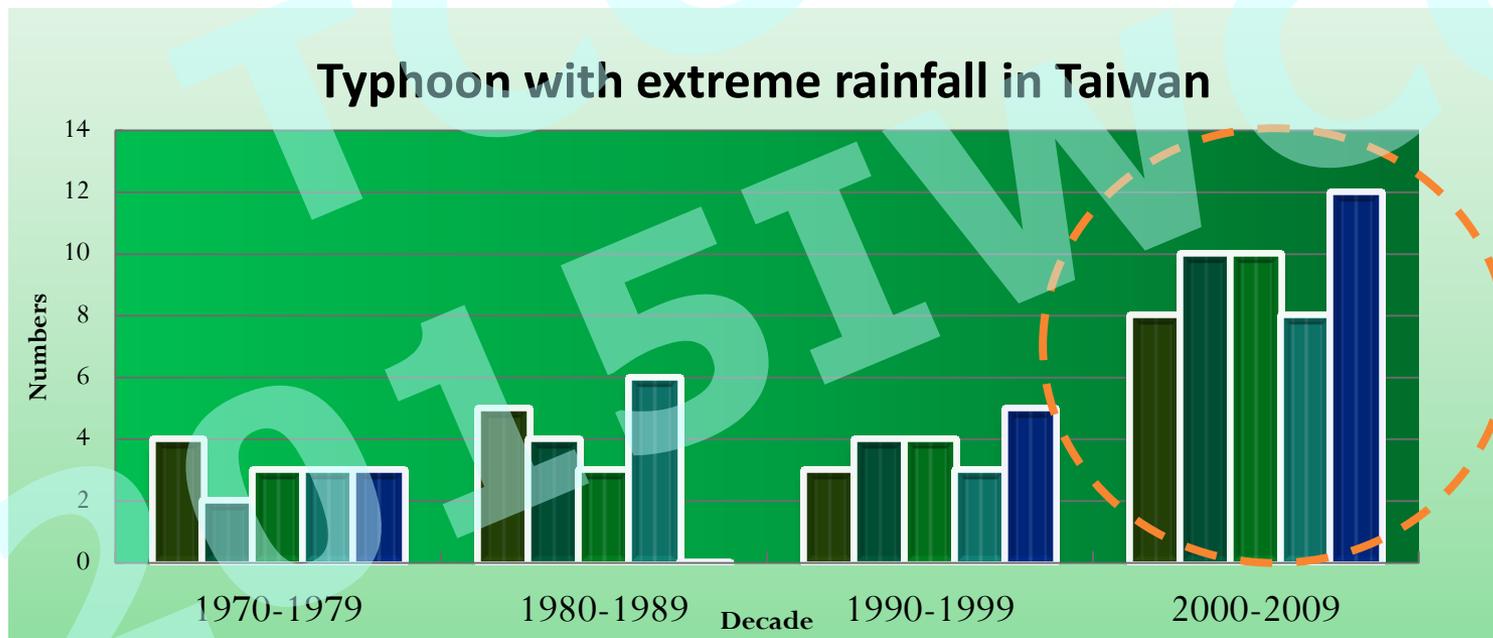


## Mei-Yu



# Typhoon with extreme rainfall

- **The increase of extreme events** is evident in recent 10 years.



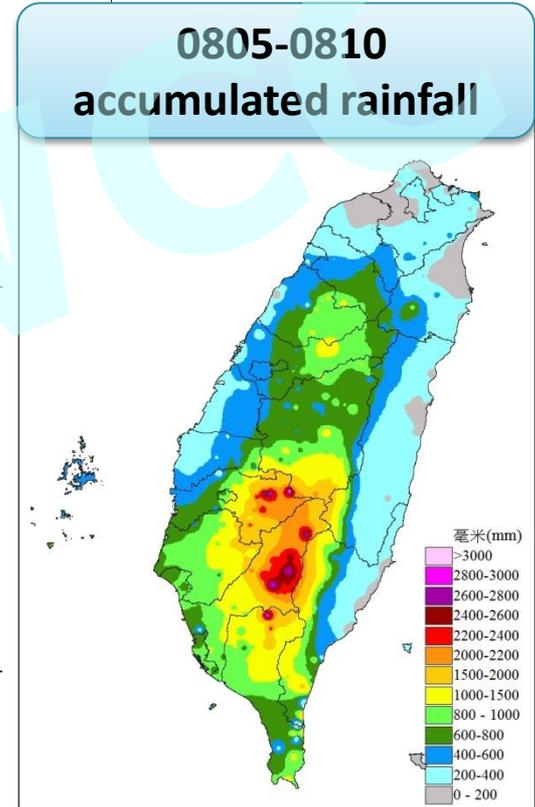
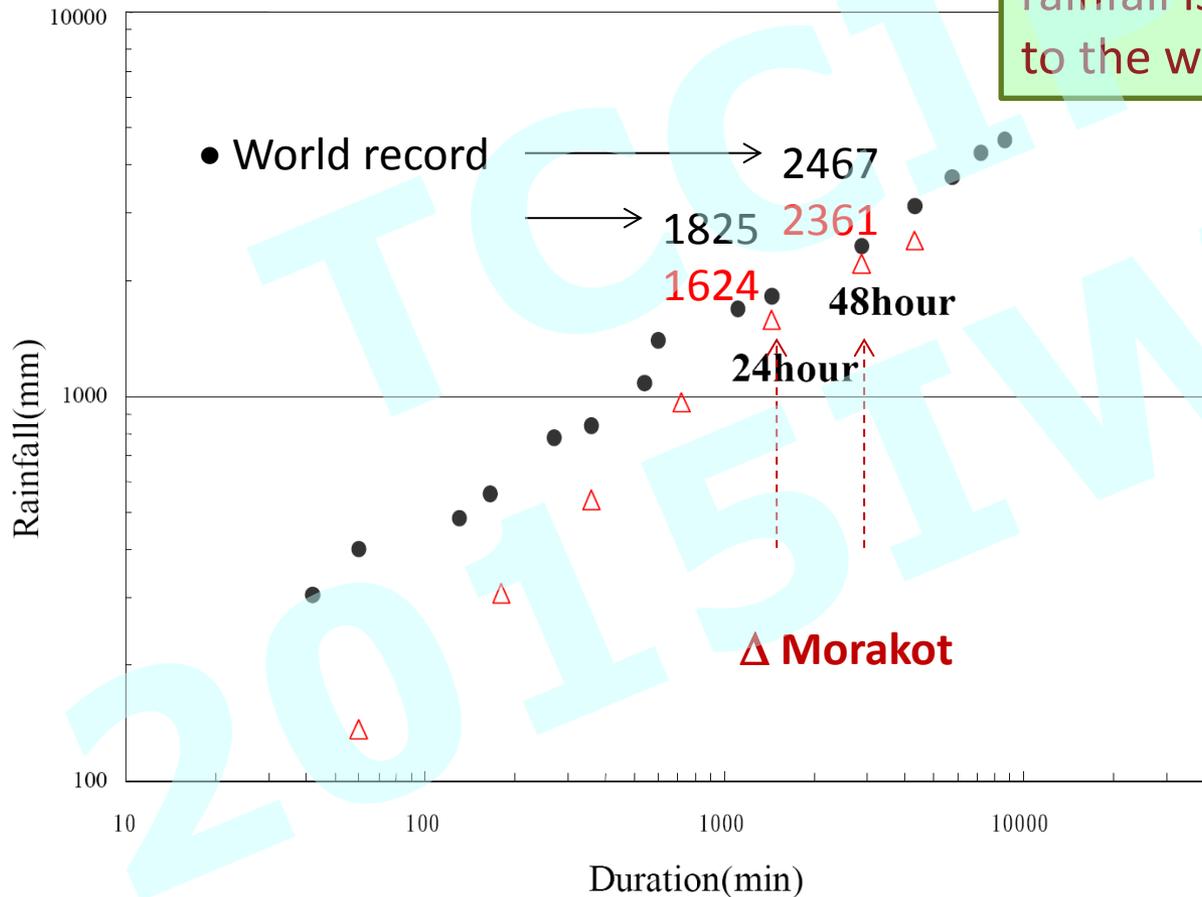
Top 20 events(195 total) was chosen by 5 extreme rainfall indices

# More and More Extreme Events in Taiwan?



- Typhoon Morakot (2009)**

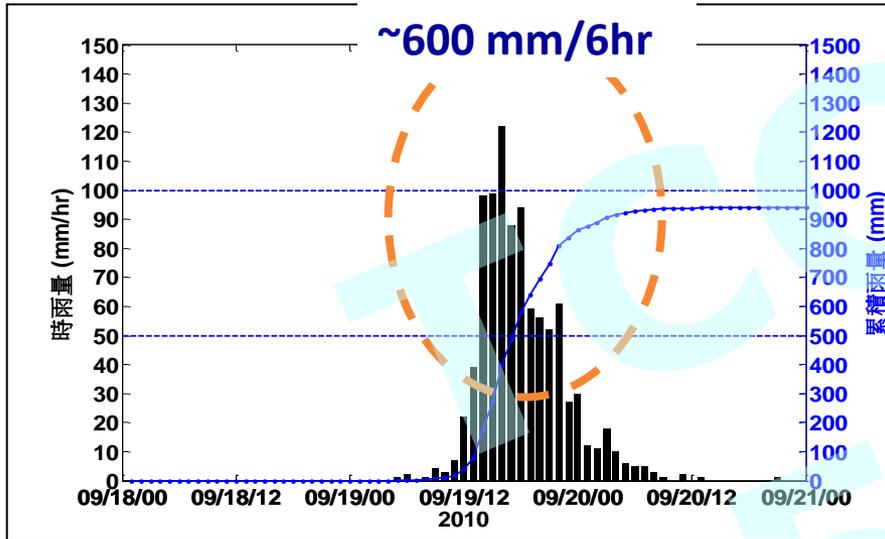
24 to 48 hours accumulated rainfall is high enough to close to the world record



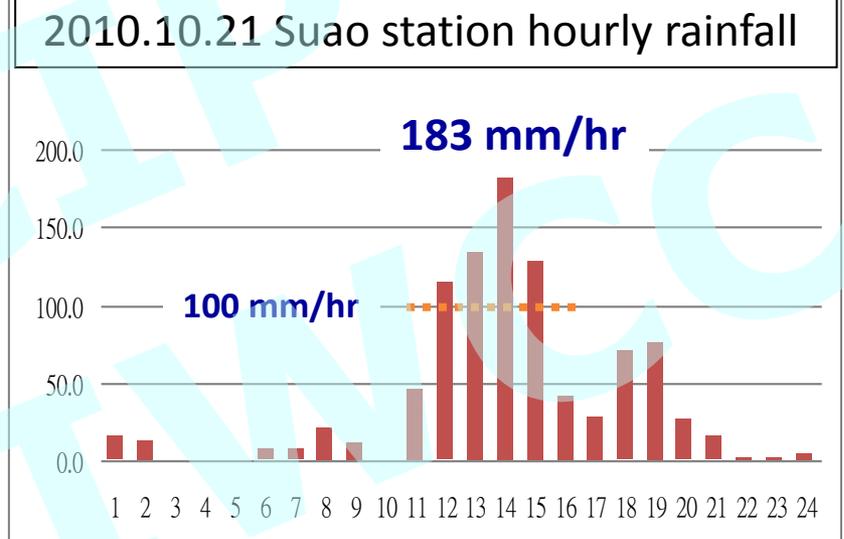
# More and More Extreme Events in Taiwan ?



## Typhoon Fanapi (2010)



## Typhoon Megi (2010)



# More and More Extreme Events in Taiwan ?



- There are some possible linkages between **extreme rainfall** and **climate change**, and we need more concrete study to identify the causing factors and ways for reduce future impact.
- In order to realize the possible trend and future scenario of climate change, Ministry of Science and Technology (MOST) launched “Taiwan Climate Change and Information Platform Project ” (**TCCIP**) at 2010 to provide scientific support to decision makers.

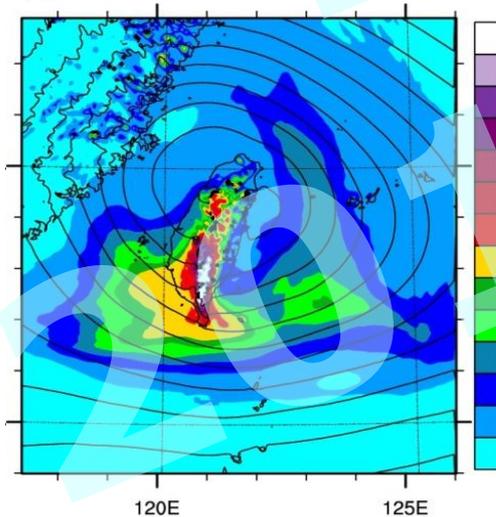
# Pseudo Global Warming Experiment for Historical Typhoons

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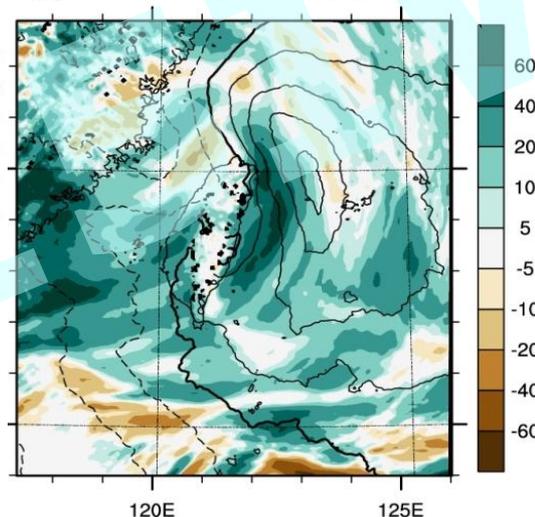


- ➔ In case typhoon relocation still miss the worst case, a perfect storm from past is moved to global-warming environment to simulate as a substitute.
- ➔ Superposition circulations of future change and historical events
  - $C_{PGW} = C_{history} + (\bar{C}_{future} - \bar{C}_{present}); \bar{C} : T, RH, U, V, \Phi, SST$
- ➔ Consider circulation change of MRI-AGCM3.2S in 2075-2099 A1B
- ➔ 2009 typhoon Morakot (top rainfall record ~3000 mm)

(a) Historical run; Mean of 48 members



(d) Rainfall change rate due to PGW

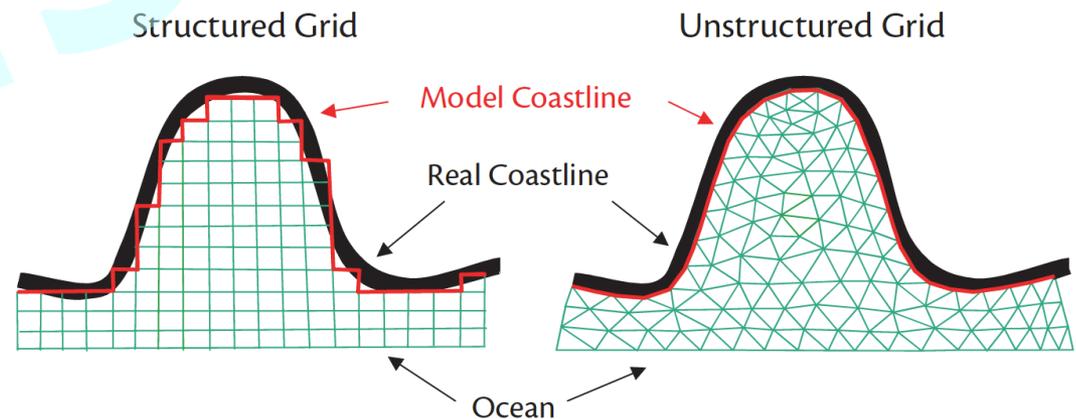


Precipitation change rate over Taiwan island can reach 40%.

Global warming may increase the impact by %?

# Inundation Model-FVCOM

- Solve the Primitive Equations : Provide **high-accuracy Simulation** for Fluid.
- Parallel Computing: Provide **high-efficiency performance**.
- Unstructured Grids: Provide the **accurate fitting** of the irregular coastal geometry.

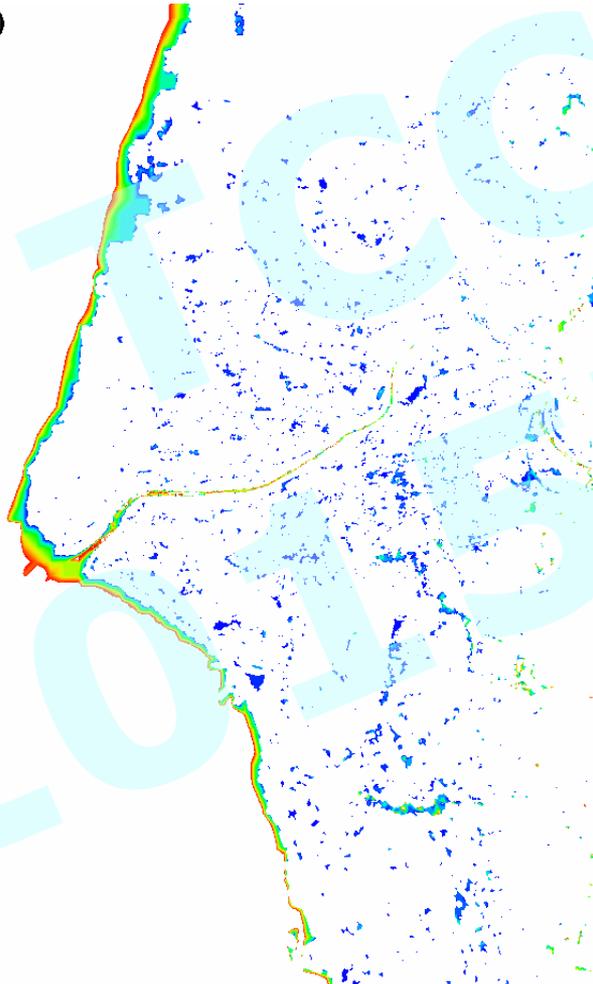
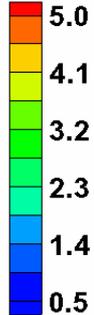


# Time-Series Distribution of Inundation Extent and Precipitation



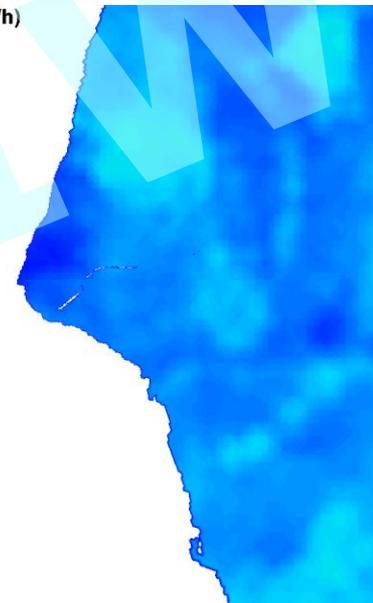
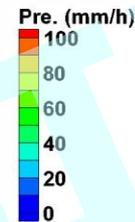
## Inundation Extent of 2009 Morakot

Inundation depth (m)



08/08/2009 0:00

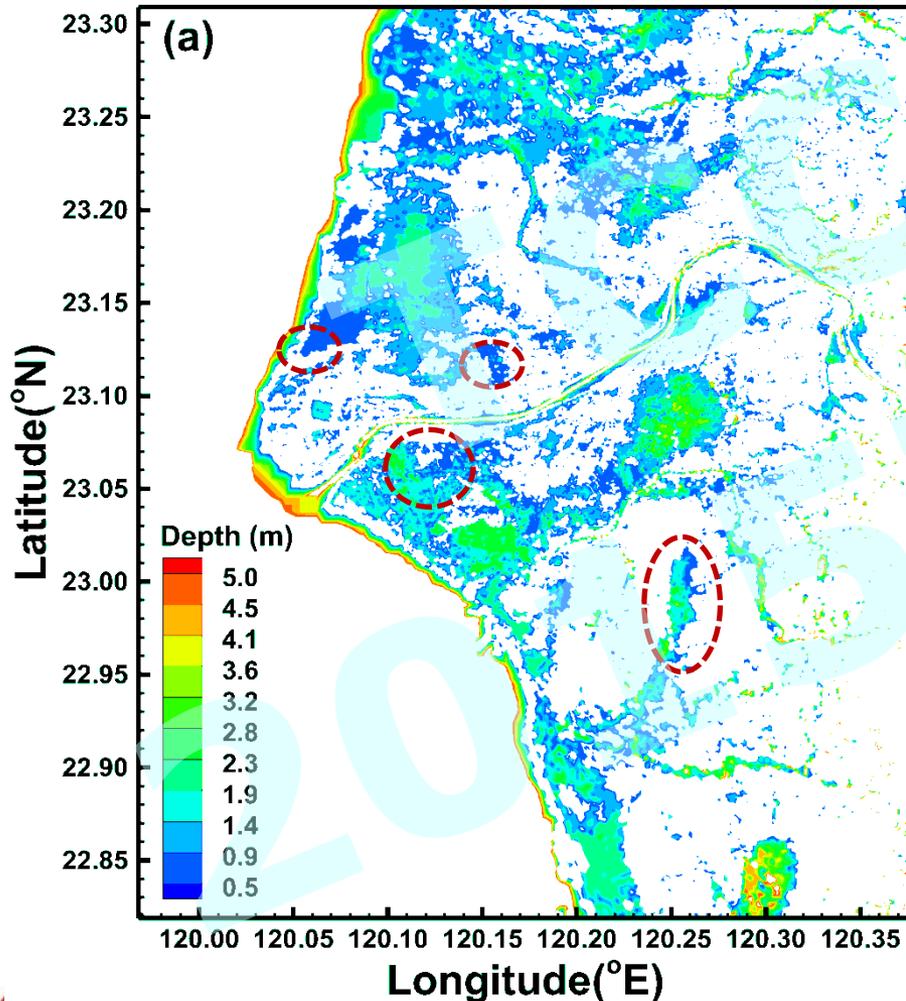
## Precipitation of 2009 Morakot



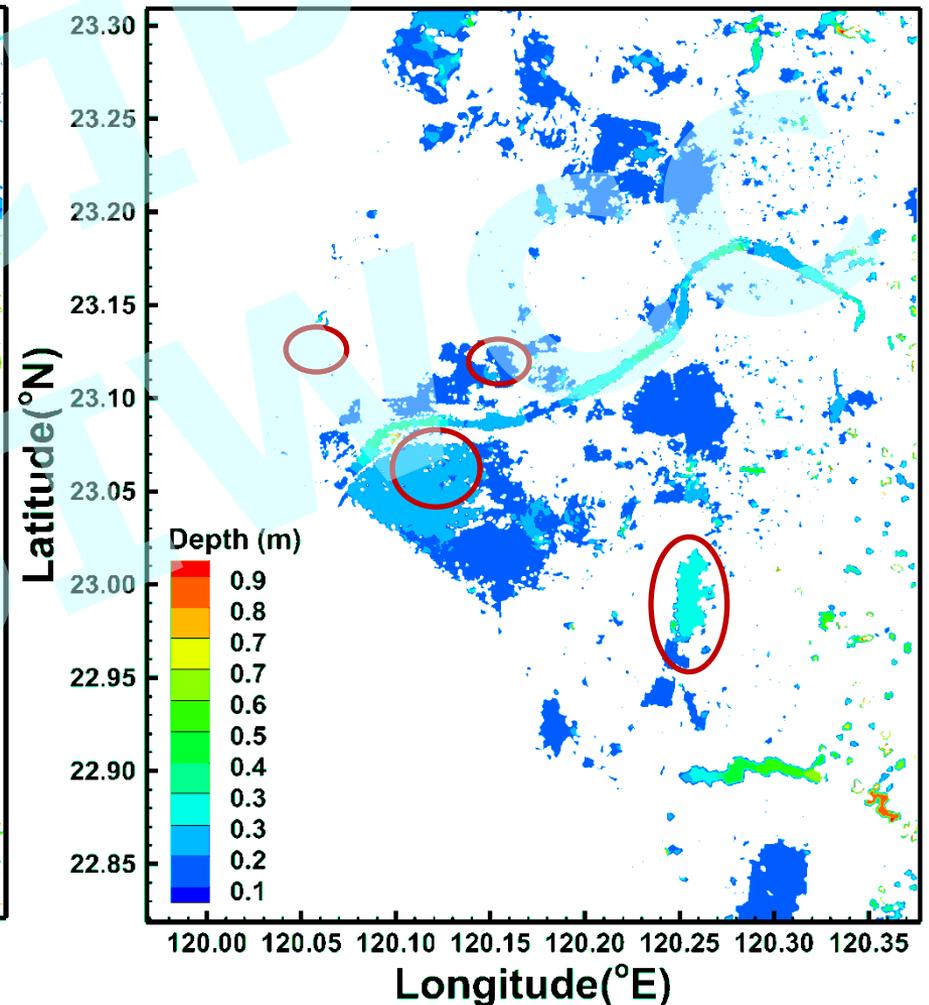
08/08/2009 0:00

# Maxi. Inundation of 2009 Morakot

## Historical event

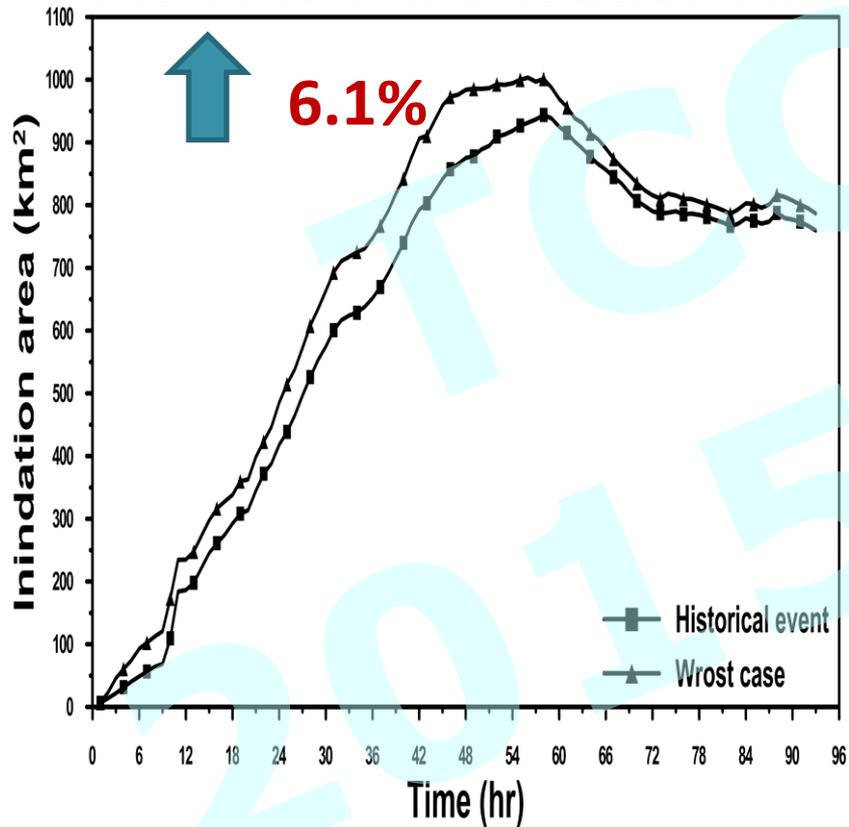


## In A1B PGW situation

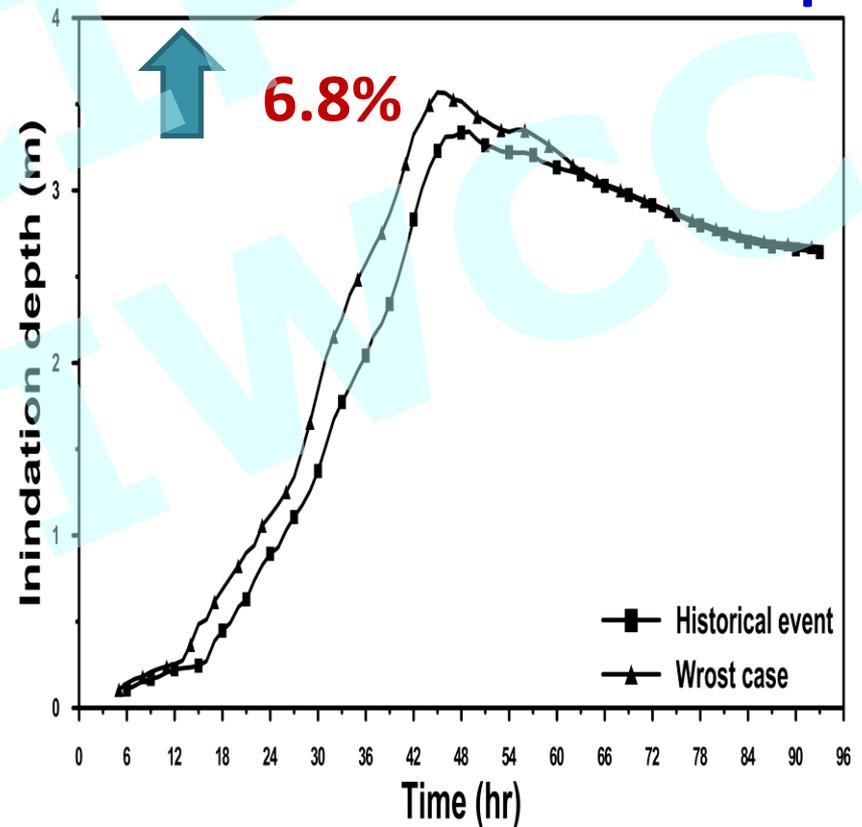


# Time series of maxi. inundation area/depth

## Maximum Inundation Area



## Maximum Inundation Depth



# Loss Assessment

TCCIP  
2015 IWCC

# Taiwan Typhoon Loss Assessment System



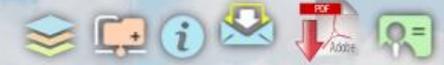
目前版本: v1.01

目前登入: 李欣



國家災害防救科技中心  
臺灣颱風洪災損評估系統  
Taiwan Typhoon Loss Assessment System

View Virtual Machine Window



比例尺:  
1 : 2279802  
目前座標:  
WGS1984: X = 121.8255, Y = 25.4702  
TWD97: X = 333010.8234, Y = 2818120.9059

淹水災害 坡地災害 資料下載

步驟 1: 請輸入此事件分析名稱 (必填) 使用說明

請選擇年度: 2011

步驟 2: 上傳崩塌範圍檔案 使用說明

※限TWD97二度分帶座標系統之ShapeFile檔案

請選擇shp檔: 上傳 shp 檔

請選擇shx檔: 上傳 shx 檔

請選擇dbf檔: 上傳 dbf 檔

自訂掩埋深度: 3 (m) 清除資料 讀取欄位

請選擇掩埋深度欄位: (m) 確定

步驟 3: 選擇欲計算的鄉鎮 使用說明

請選擇鄉鎮:

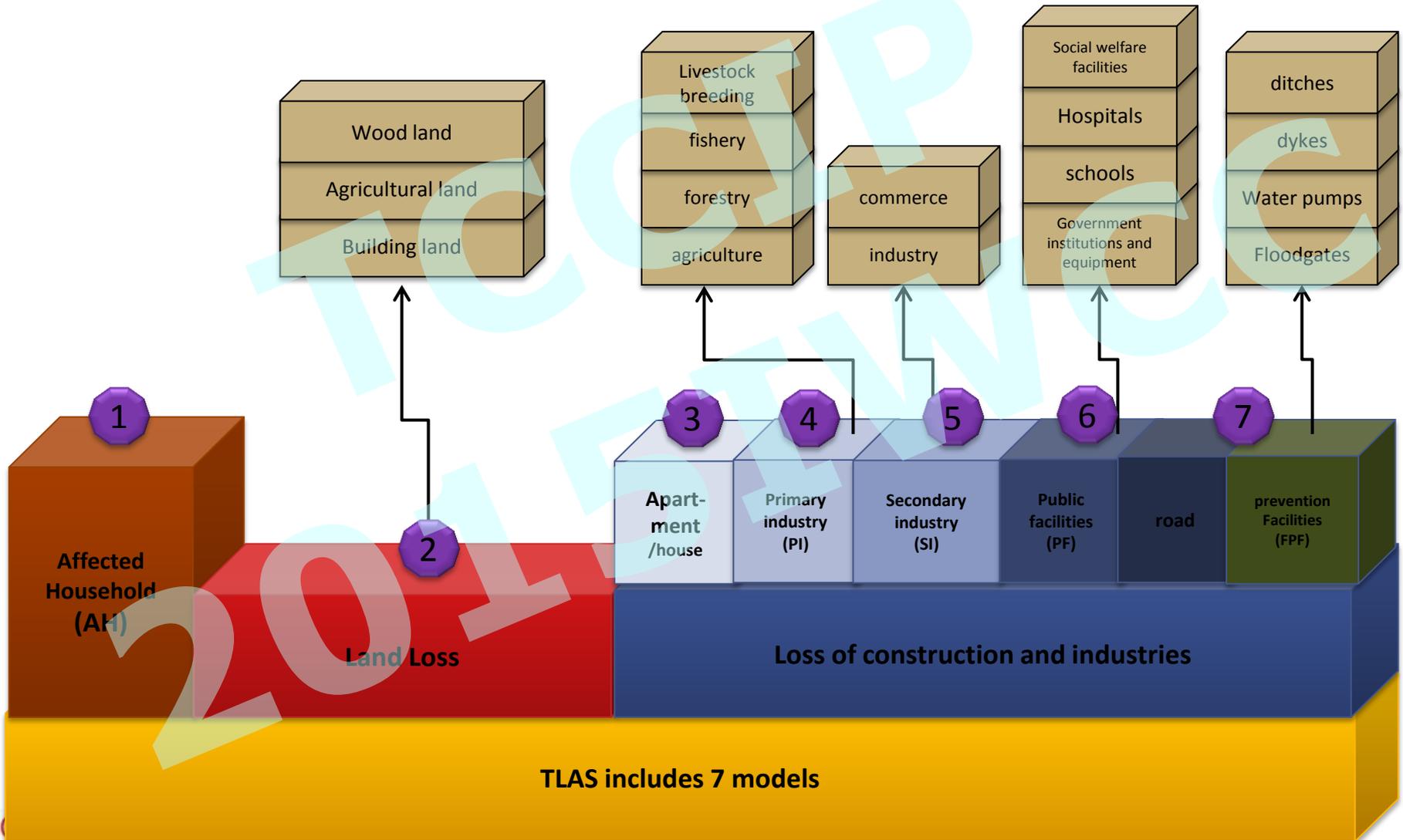
※系統計算結果會以Email通知

請輸入您的Email(必填):

開始執行

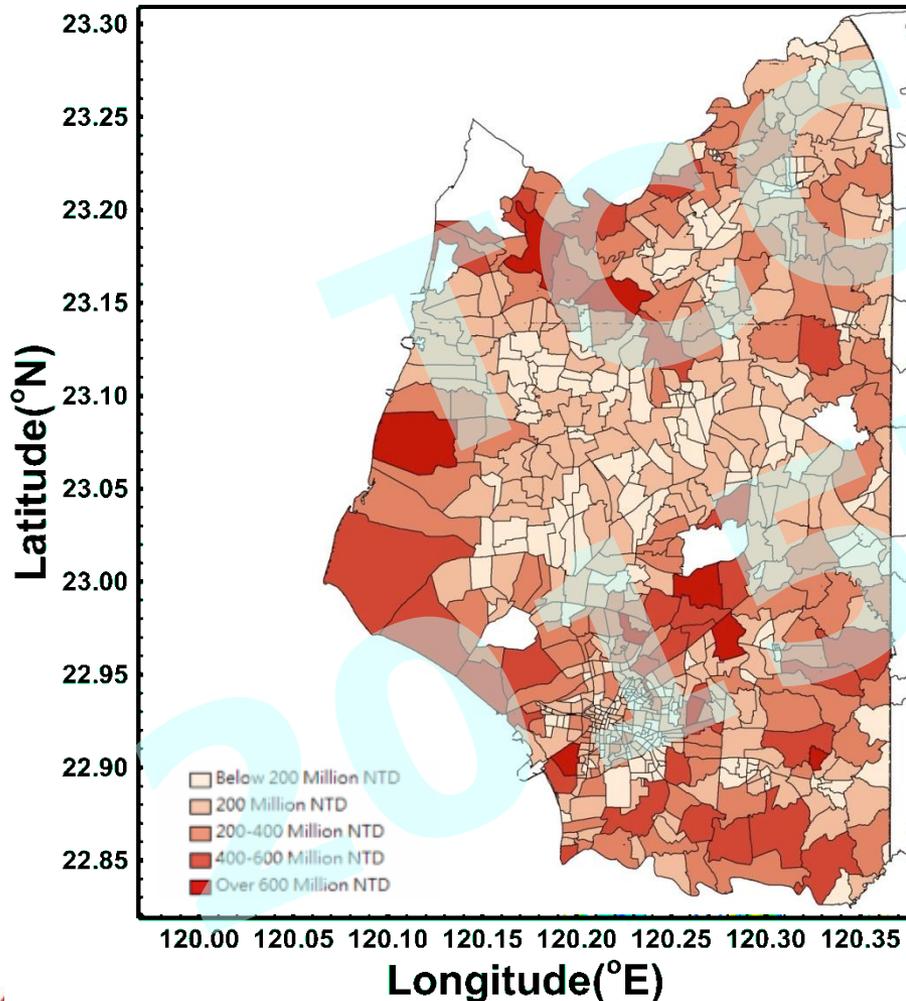


# TLAS Taiwan Framework

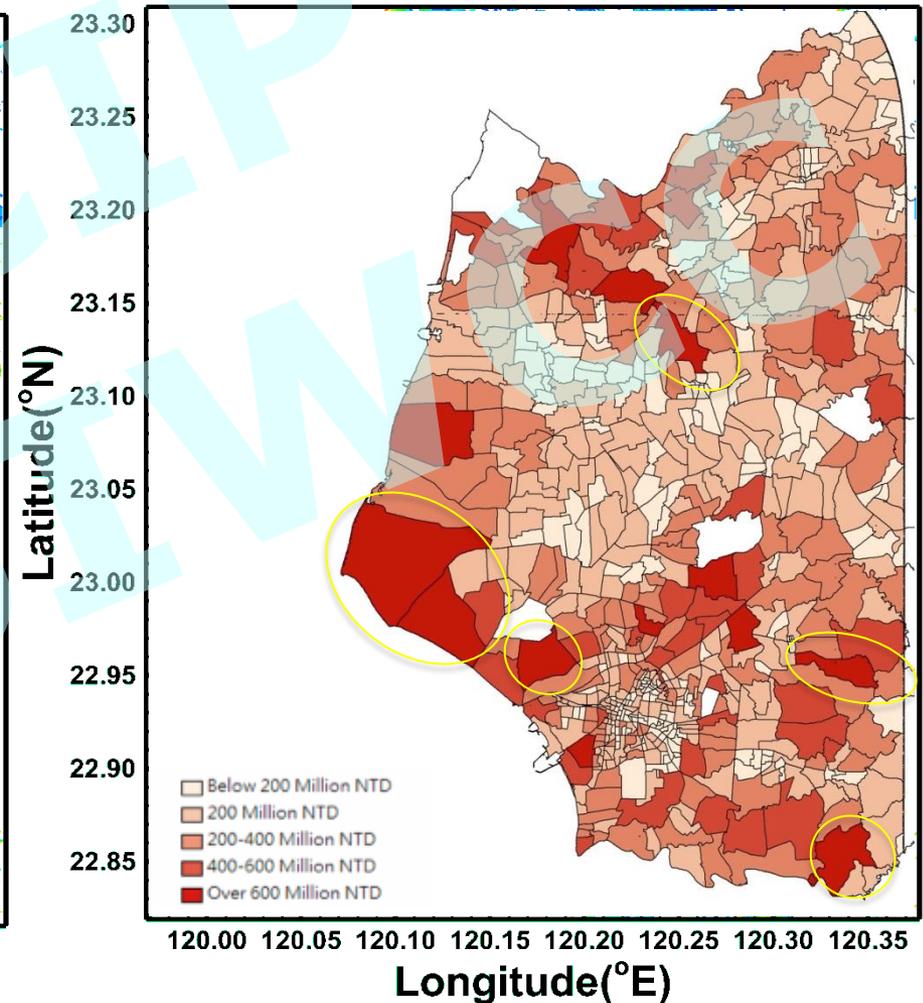


# Flood Loss Assessment

## Historical event



## In A1B PGW situation



# Flood Loss Difference

Agriculture and Aquaculture Industry Area



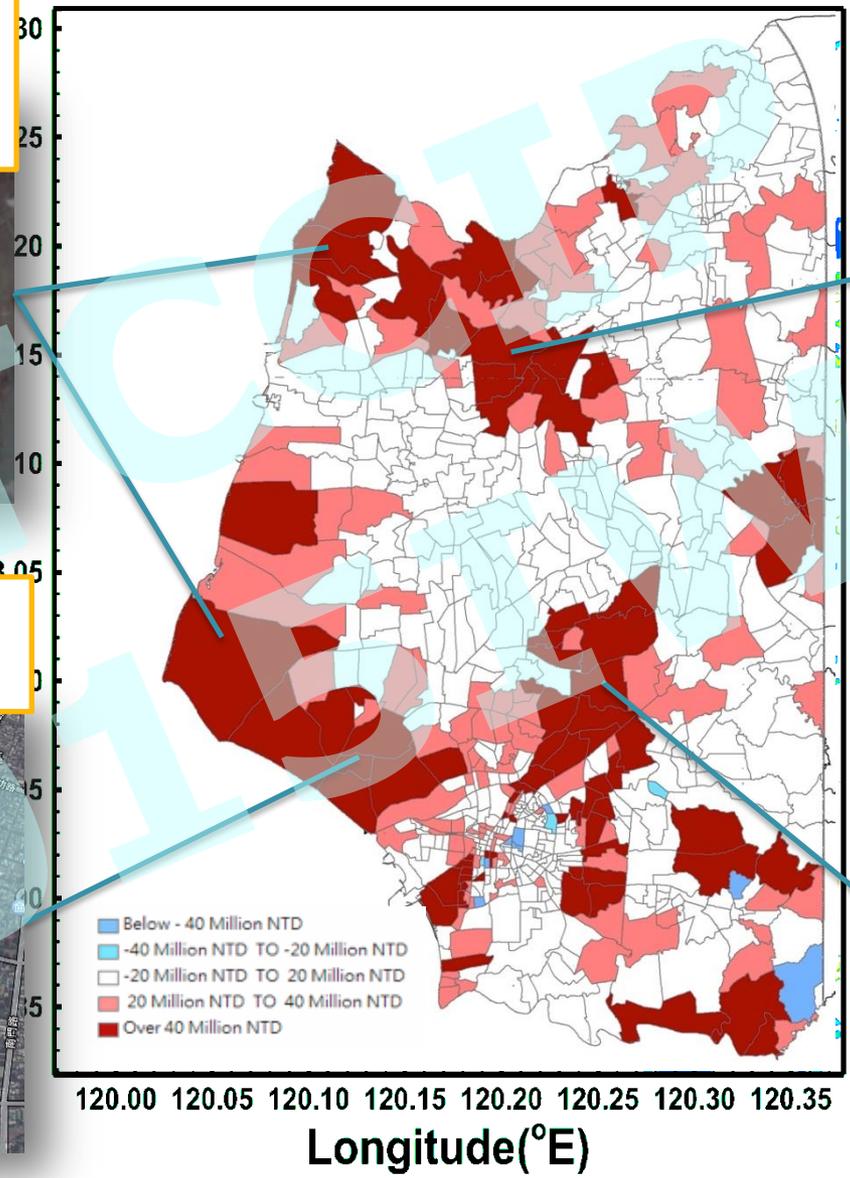
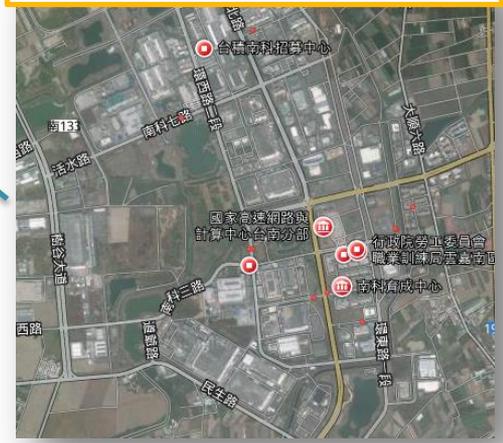
Xue-Jia Suburb Housing Area



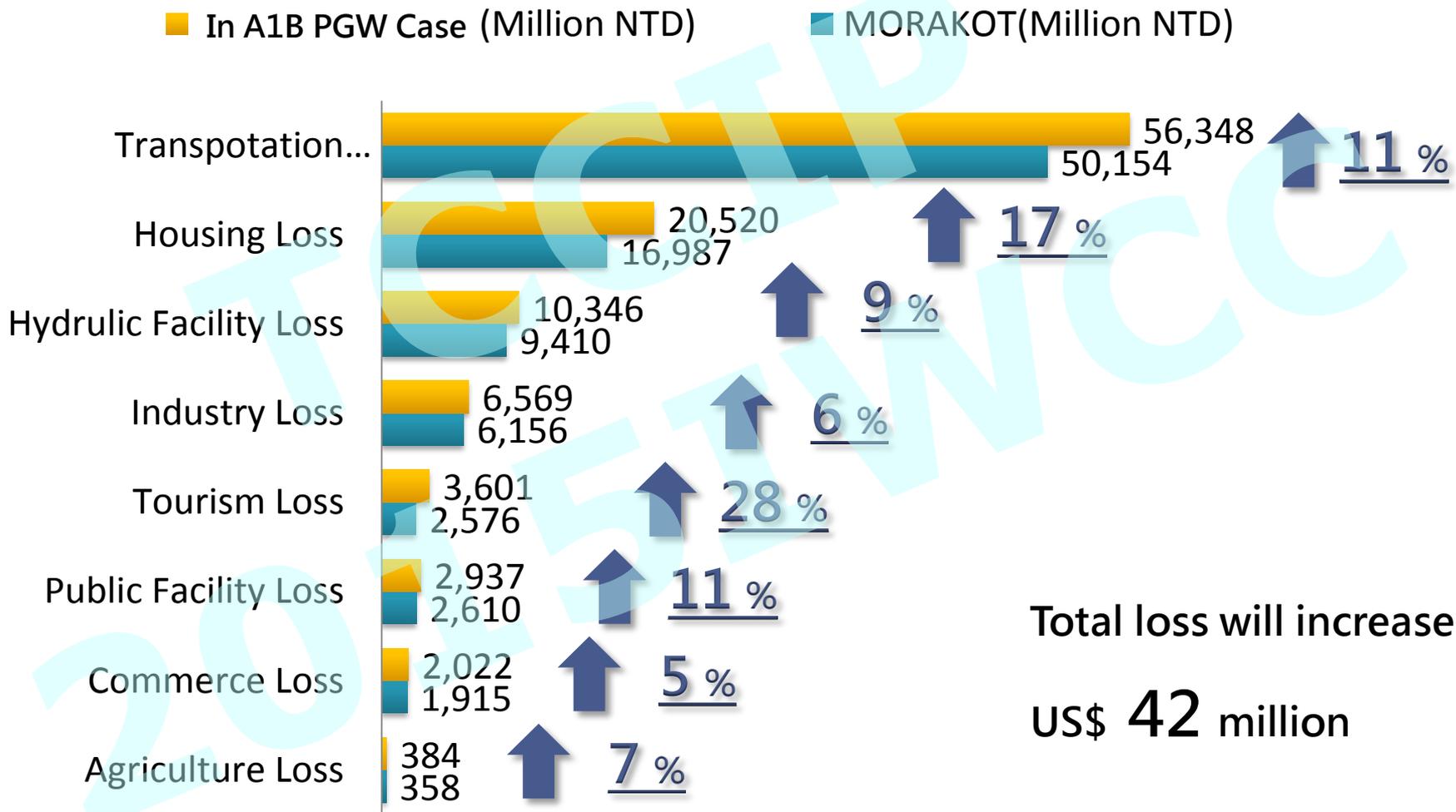
Tai-Nan City Downtown



Tan-Nan Science Park



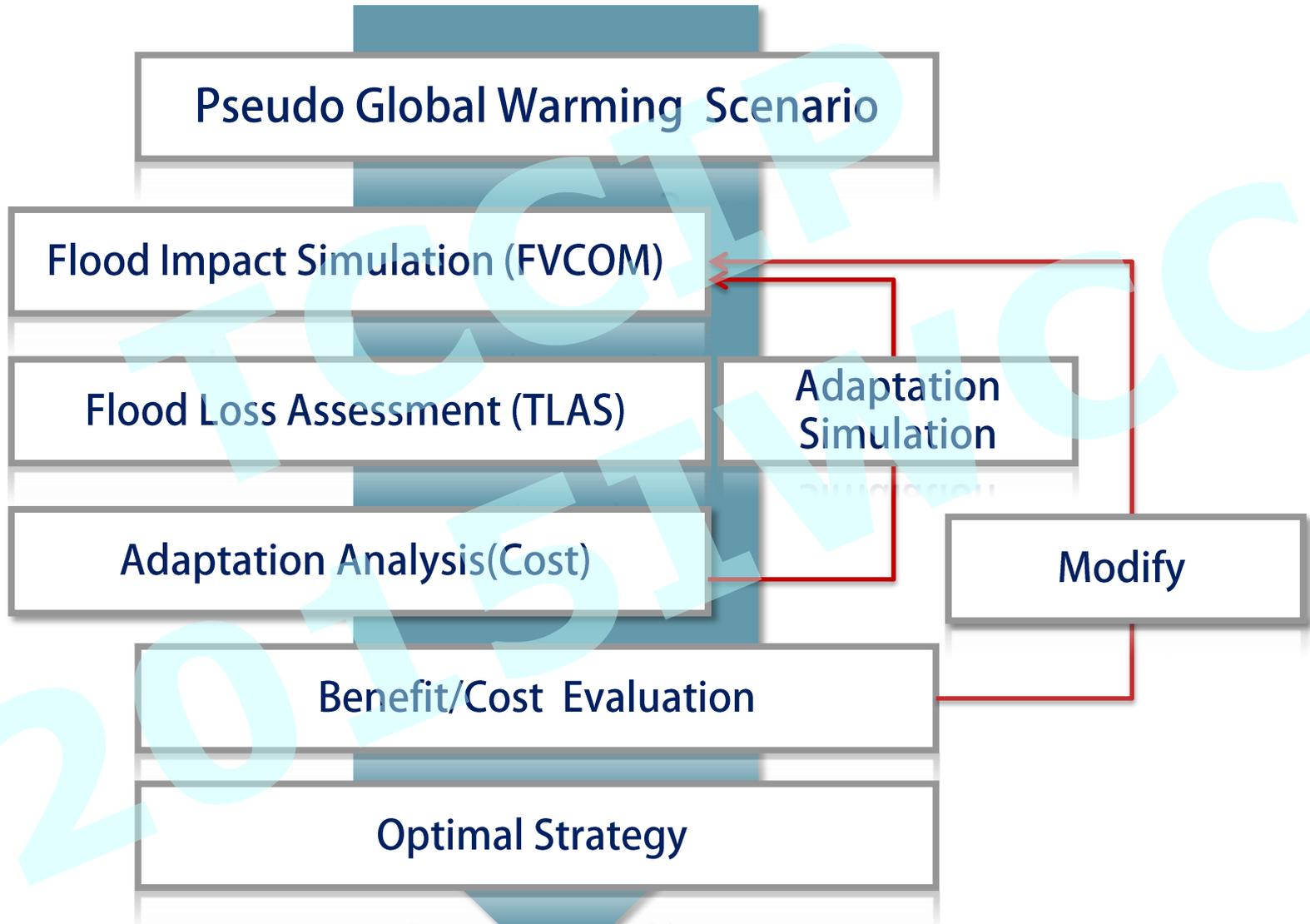
# Loss Difference Under Different Land Use



Total loss will increase  
US\$ 42 million

0 20,000 40,000 60,000

# Optimal Adaptation Method



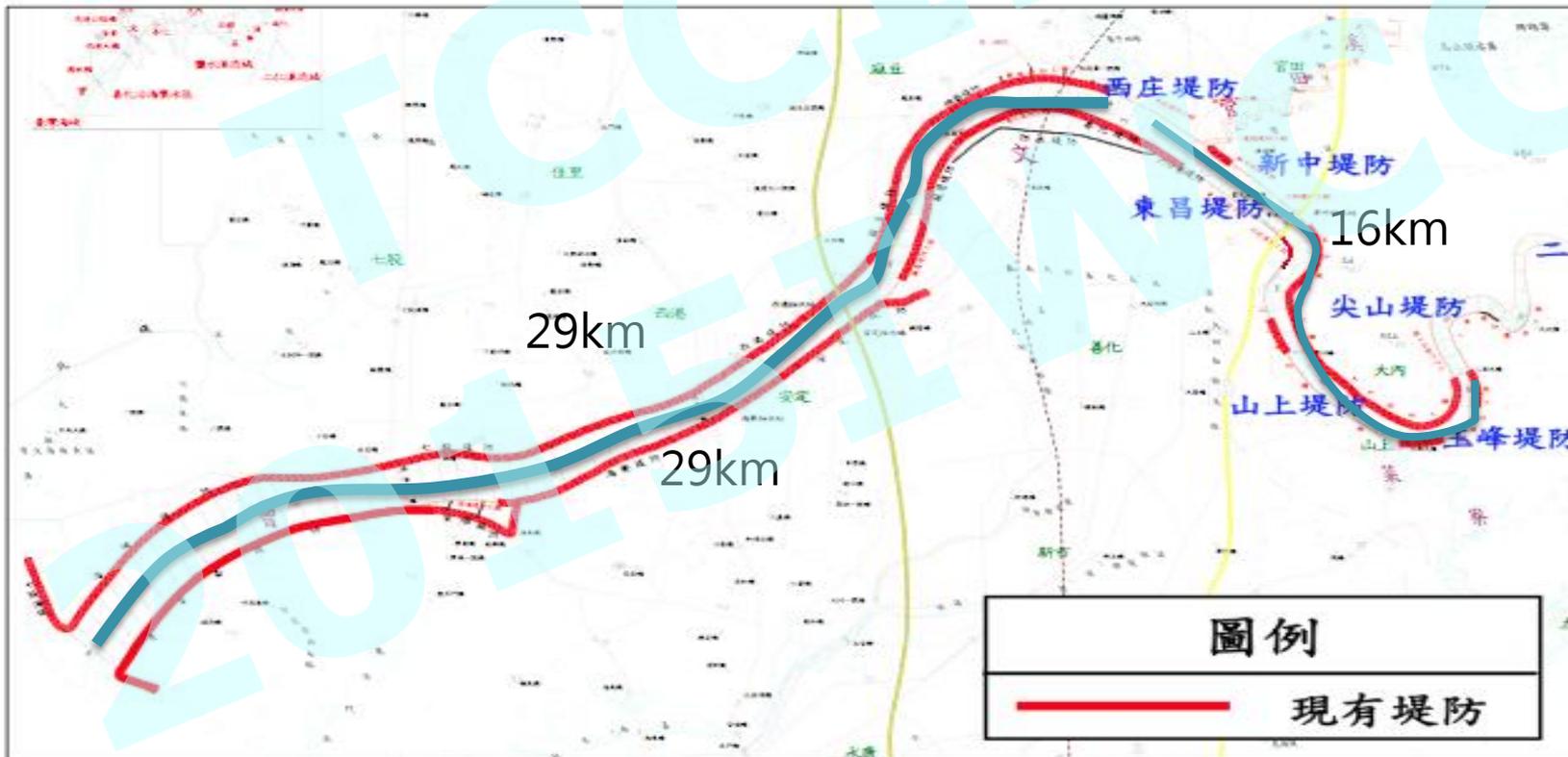
# Flood Engineering Adaption Options



Project	Method	Content
Project 1	Strengthen flood prevention facilities	Raise up embankments
Project 2	Increase detention space at the midstream	Build detention pools
Project 3	Improve downstream rainwater catchment	Infiltration facility of schools
Project 4	Improve downstream rainwater catchment	Infiltration facility of public parks
Project 5	Increase the river basin's capacity	Flood diversion, sediment dredging
Project 6	Improve downstream run-off management	Pump stations

# Project 1

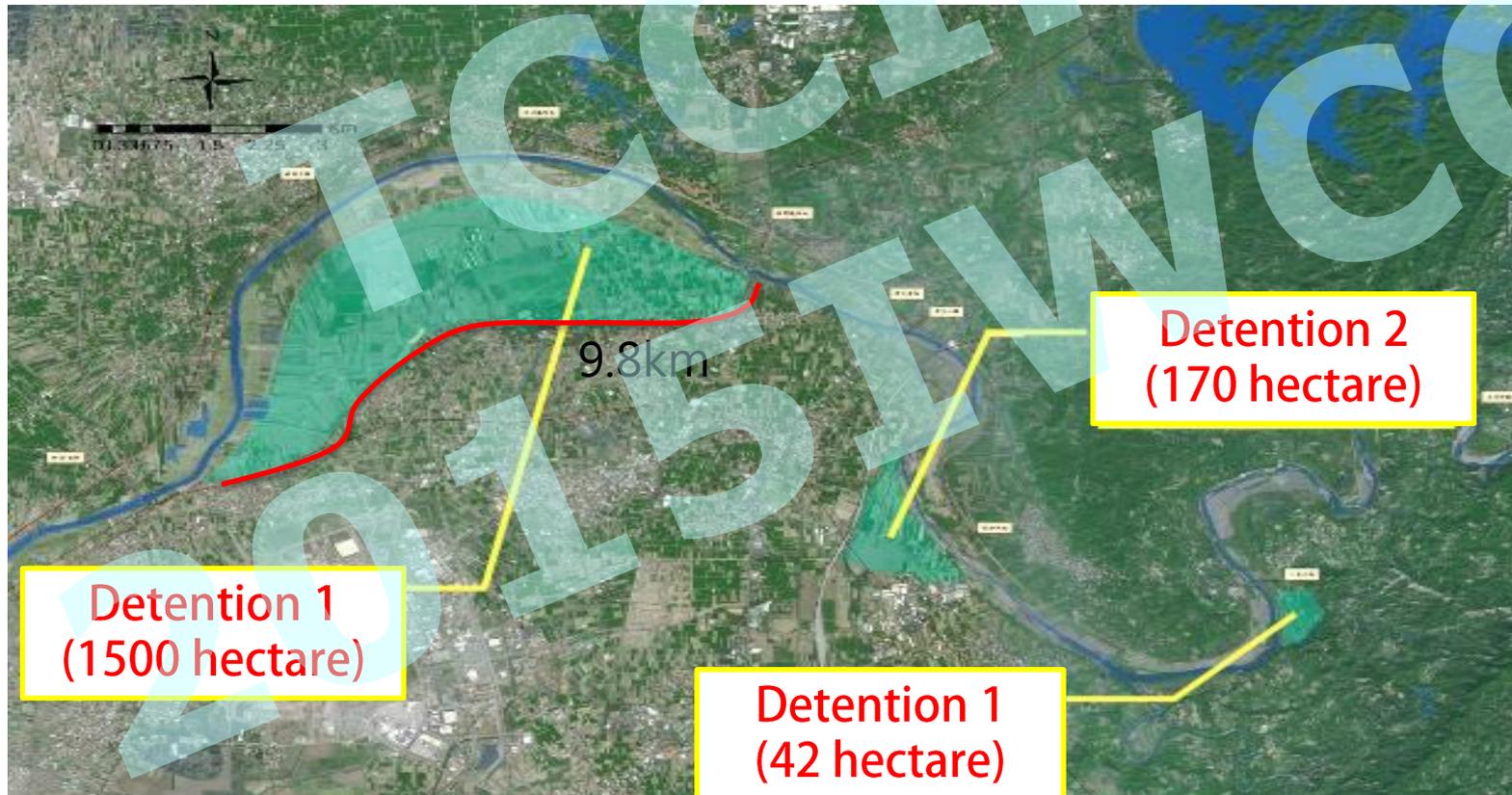
PROJECT	Method	Content
Project 1	Strengthen flood prevention facilities	Raise up embankments 0.5m



Source : Water Resource Agency

# Project 2

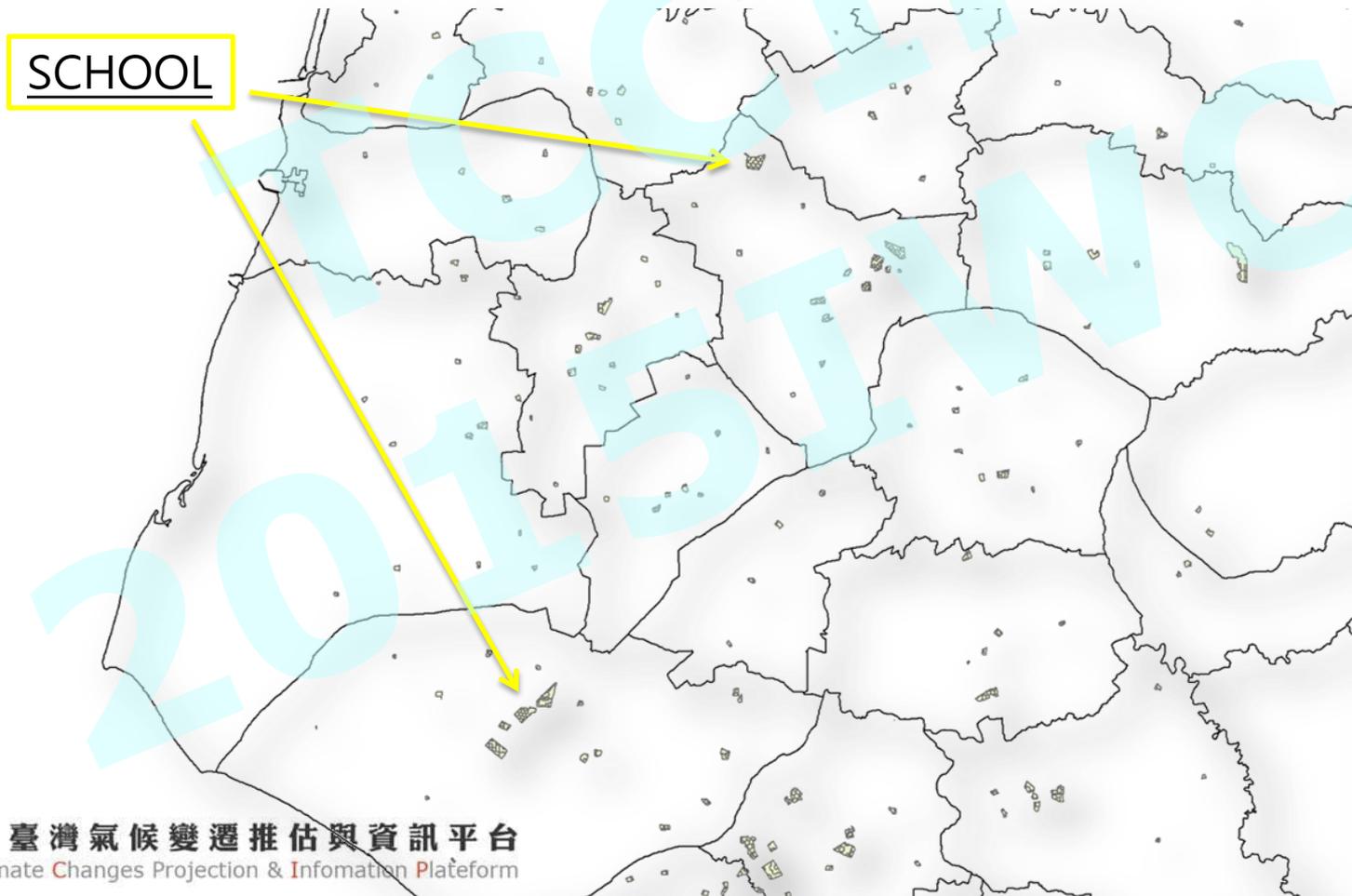
PROJECT	Method	Content
Project 2	Increase detention space at the midstream	Build detention pools



Source : Water Resource Agency

# Project 3

PROJECT	Method	Content
Project 3	Improve downstream rainwater catchment	Infiltration facility of schools (1200 hectare)



# Taiwan Case



Dig 50 cm depth

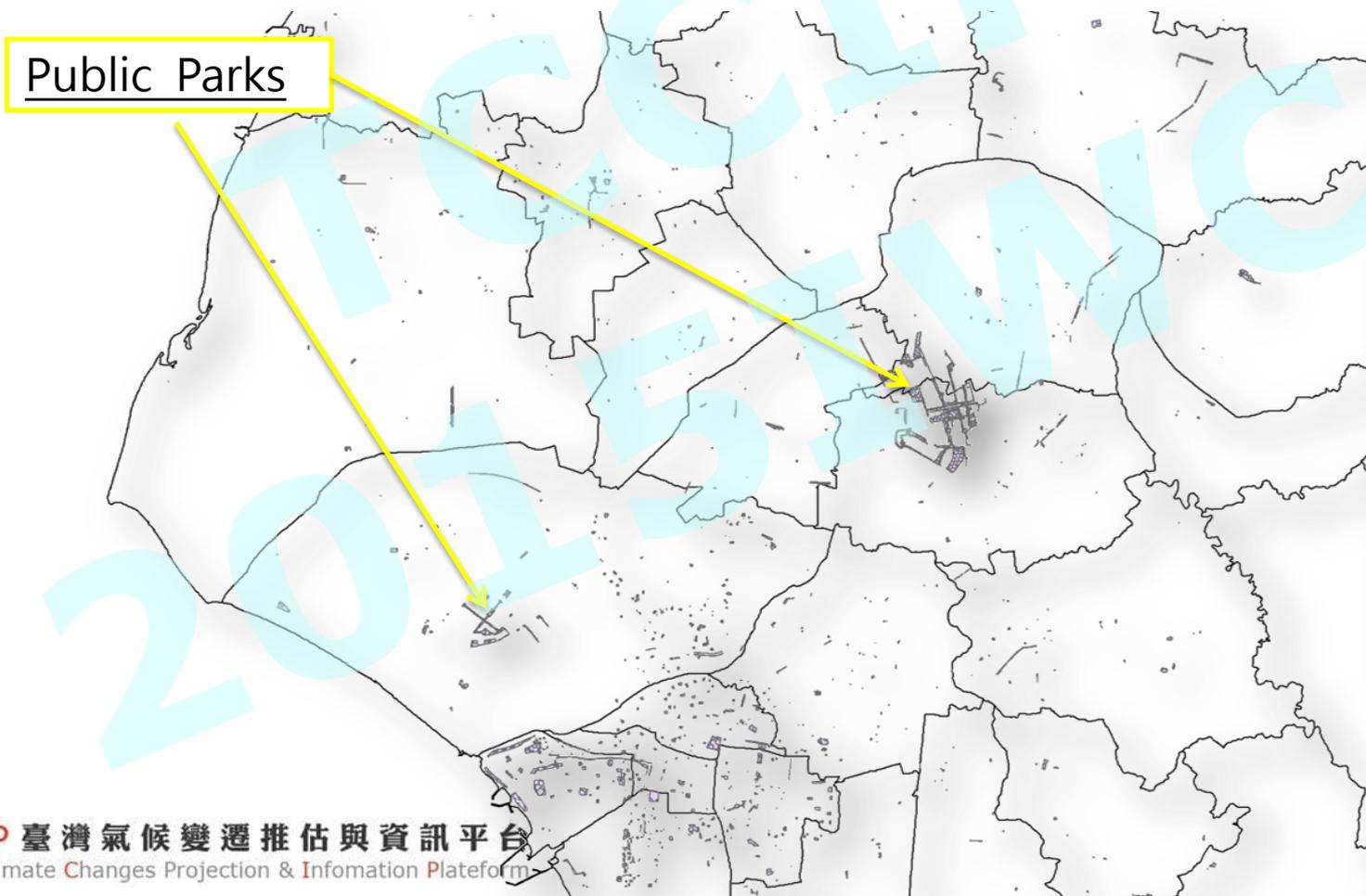


Park lot 18 cm depth



# Project 4

PROJECT	Method	Content
Project 4	Improve downstream rainwater catchment	Infiltration facility of public parks (1200 hectare)



# America Case



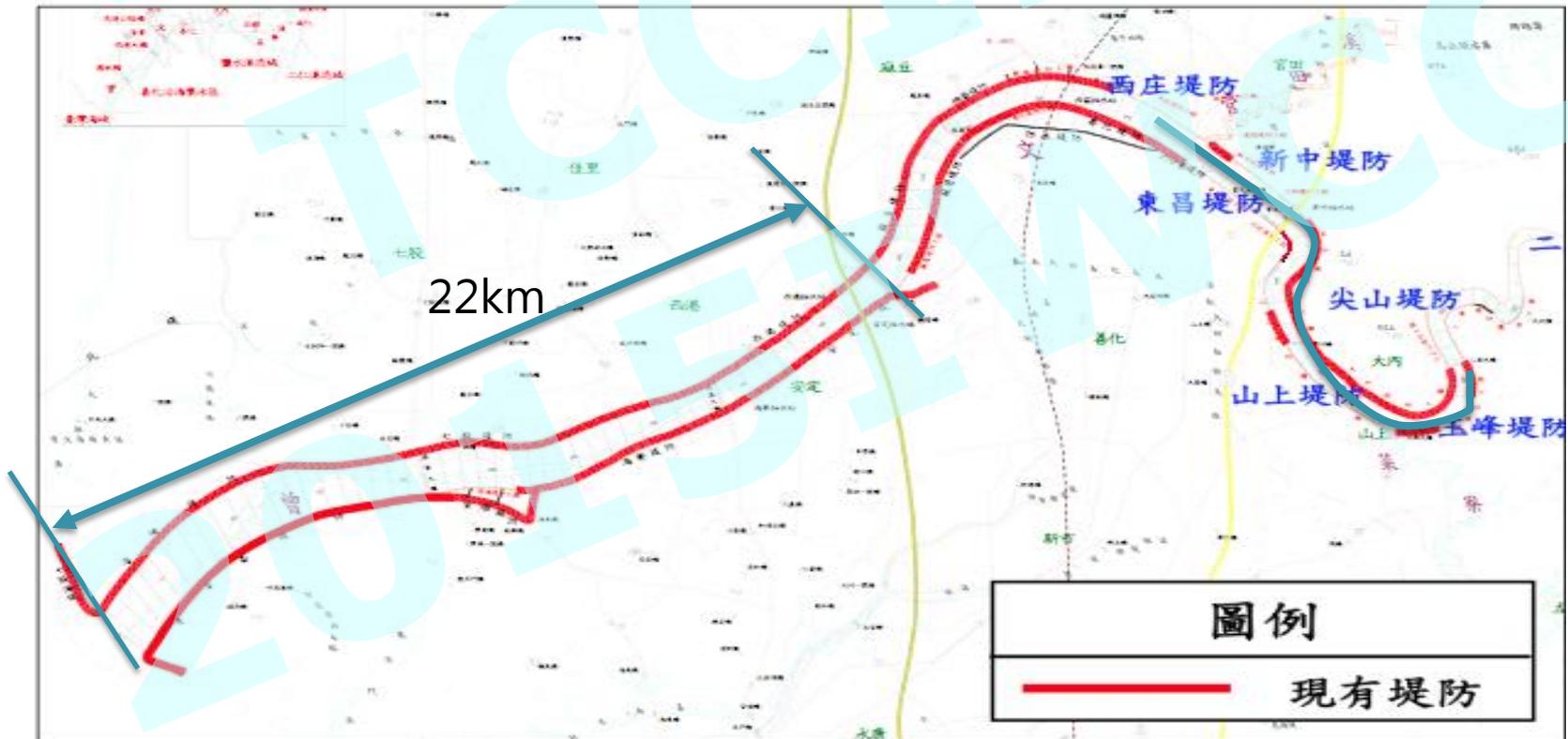
## Surface runoff control



Source : Water Resource Agency

# Project 5

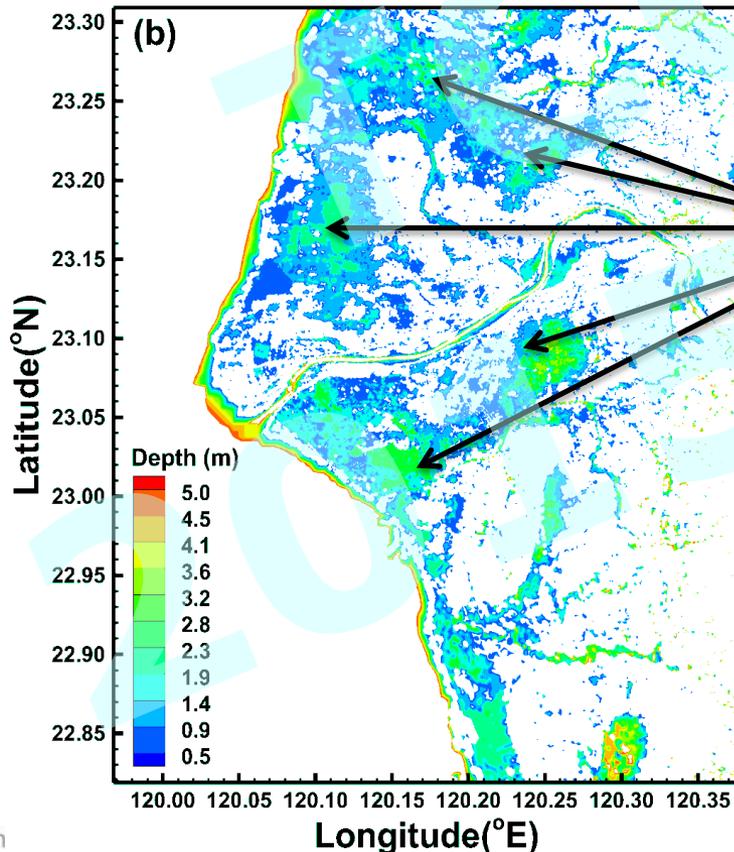
PROJECT	Method	Content
Project 5	Increase the river basin' s capacity	Sediment dredging 1m



Source : Water Resource Agency

# Project 6

PROJECT	Method	Content
Project 6	Improve downstream run-off management	Build pump stations or set up pump machines



Regional drainage and sewer system (Pump stations or set up pump machines)

# Cost Analysis of Adaptations (1/2)



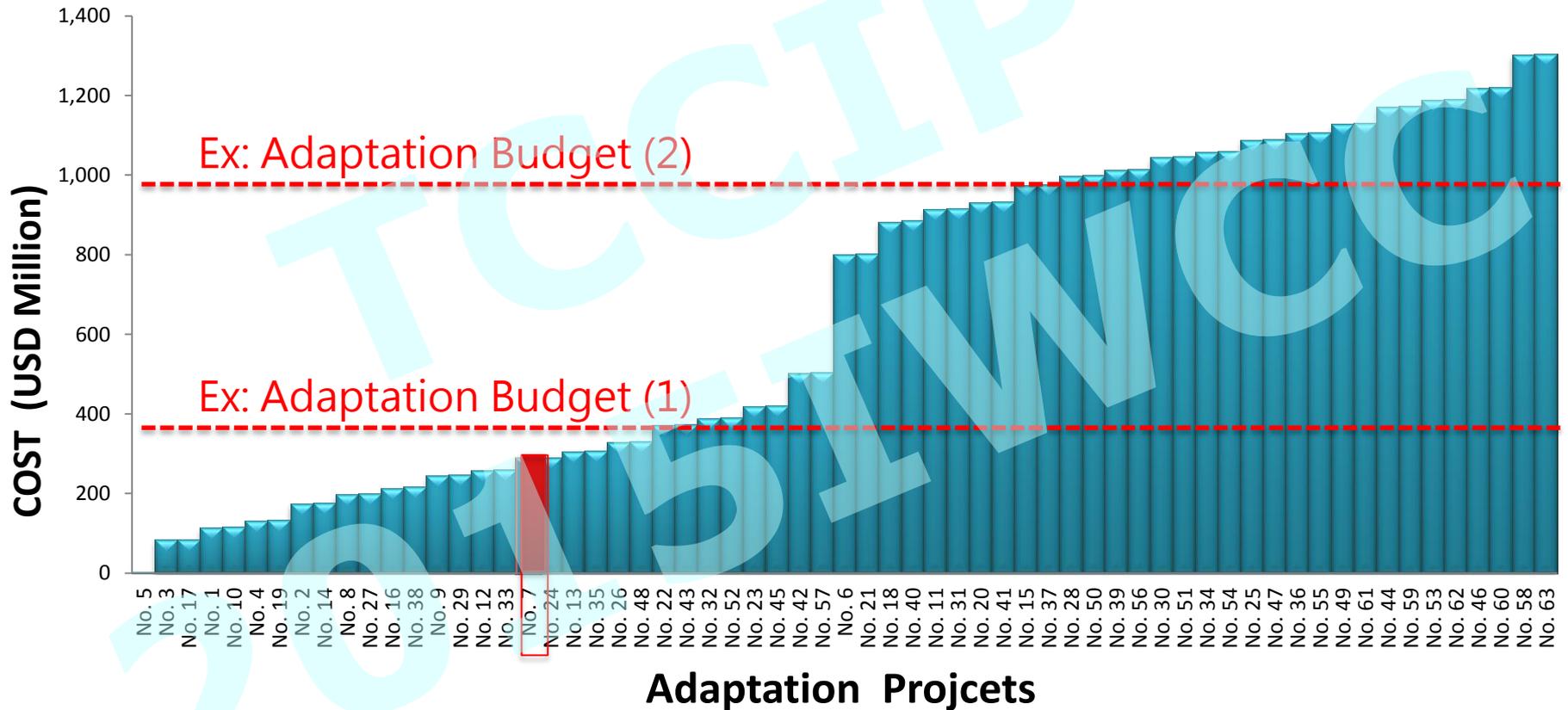
Strategy	Combine project	Strategy	Combine project
1	p1	17	p3+p5
2	p2	18	p3+p6
3	p3	19	p4+p5
4	p4	20	p4+p6
5	p5	21	p5+p6
6	p6	22	p1+p2+p3
7	p1+p2	23	p1+p2+p4
8	p1+p3	24	p1+p2+p5
9	p1+p4	25	p1+p2+p6
10	p1+p5	26	p1+p3+p4
11	p1+p6	27	p1+p3+p5
12	p2+p3	28	p1+p3+p6
13	p2+p4	29	p1+p4+p5
14	p2+p5	30	p1+p4+p6
15	p2+p6	31	p1+p5+p6
16	p3+p4	32	p2+p3+p4

# Cost Analysis of Adaptations (2/2)



Strategy	Combine project	Strategy	Combine project
33	p2+p3+p5	49	p1+p3+p4+p6
34	p2+p3+p6	50	p1+p3+p5+p6
35	p2+p4+p5	51	p1+p4+p5+p6
36	p2+p4+p6	52	p2+p3+p4+p5
37	p2+p5+p6	53	p2+p3+p4+p6
38	p3+p4+p5	54	p2+p3+p5+p6
39	p3+p4+p6	55	p2+p4+p5+p6
40	p3+p5+p6	56	p3+p4+p5+p6
41	p4+p5+p6	57	p1+p2+p3+p4+p5
42	p1+p2+p3+p4	58	p1+p2+p3+p4+p6
43	p1+p2+p3+p5	59	p1+p2+p3+p5+p6
44	p1+p2+p3+p6	60	p1+p2+p4+p5+p6
45	p1+p2+p4+p5	61	p1+p3+p4+p5+p6
46	p1+p2+p4+p6	62	p2+p3+p4+p5+p6
47	p1+p2+p5+p6	63	p1+p2+p3+p4+p5+p6
48	p1+p3+p4+p5		

# Adaptations Cost



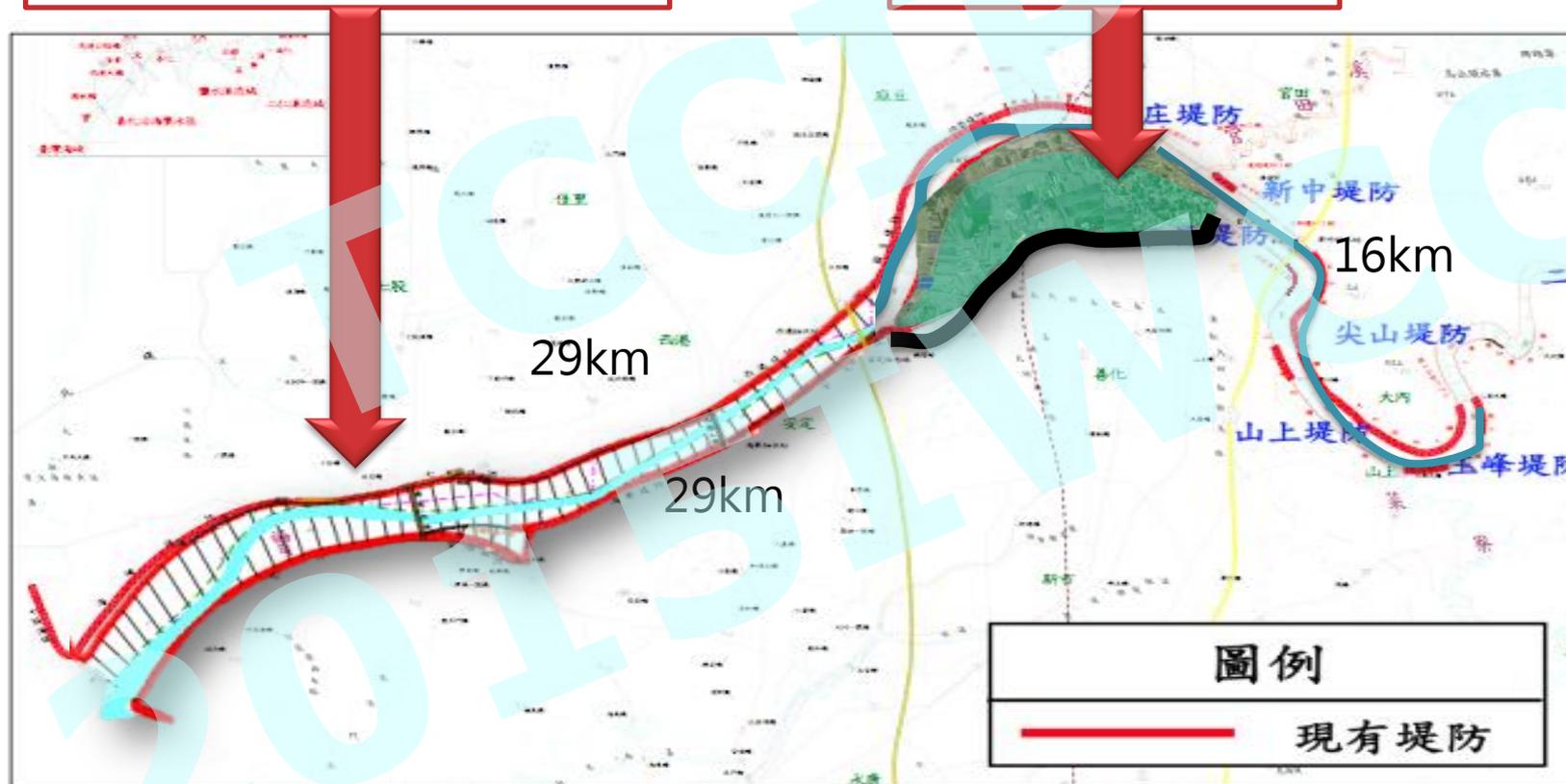
# Strategy 7 \_case study

## Project 1

Raise up embankments 0.5m

## Project 2

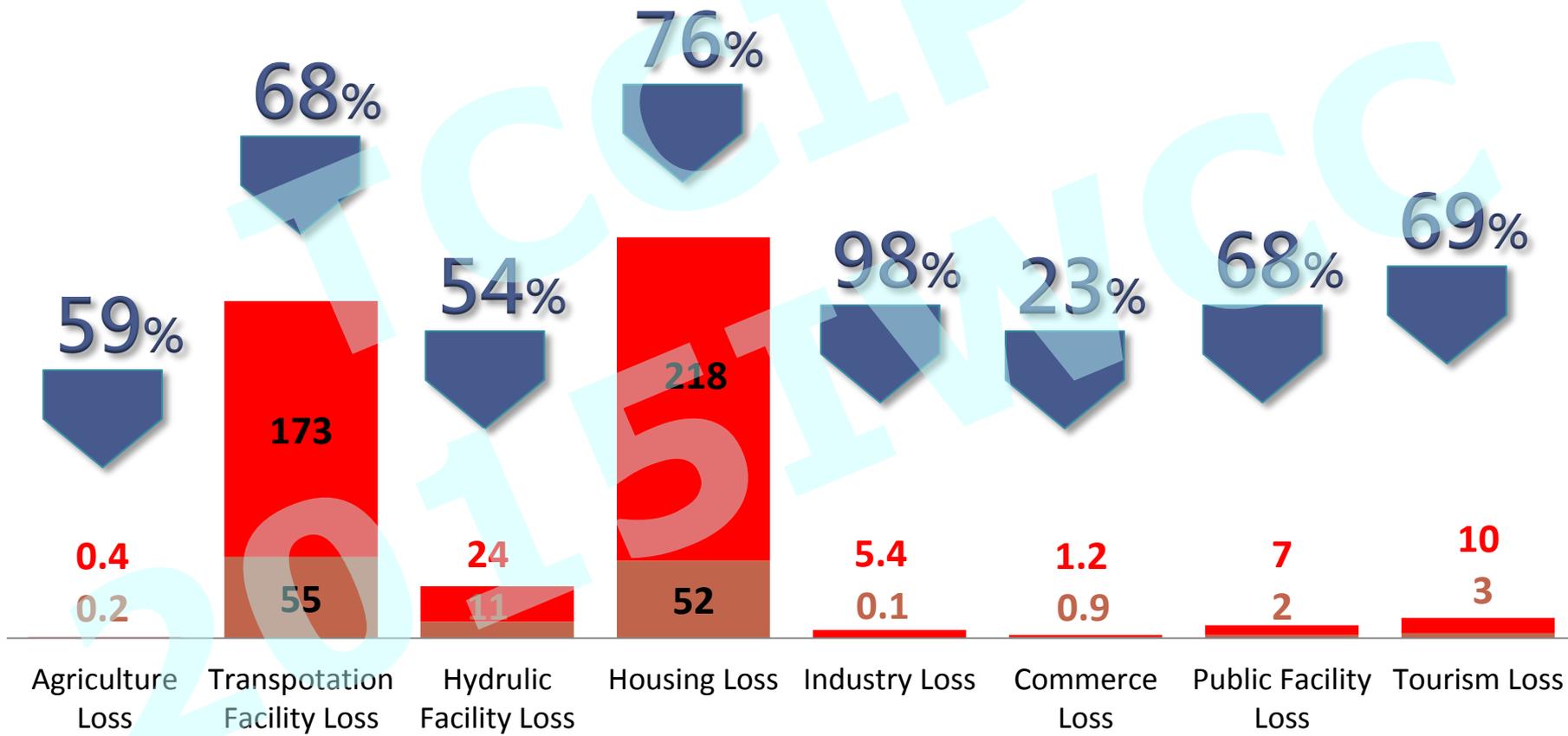
Build detention pool



# Strategy 7 \_ benefit analysis



■ After Adaptation Loss (Billion NTD)    ■ Before Adaptation Loss (Billion NTD)



**Thanks for your attention**