中央大学
CHUO UNIVERSITY
Knowledge into Action

# Climate Change Risk in Megacities
# – A case study of Bangkok –

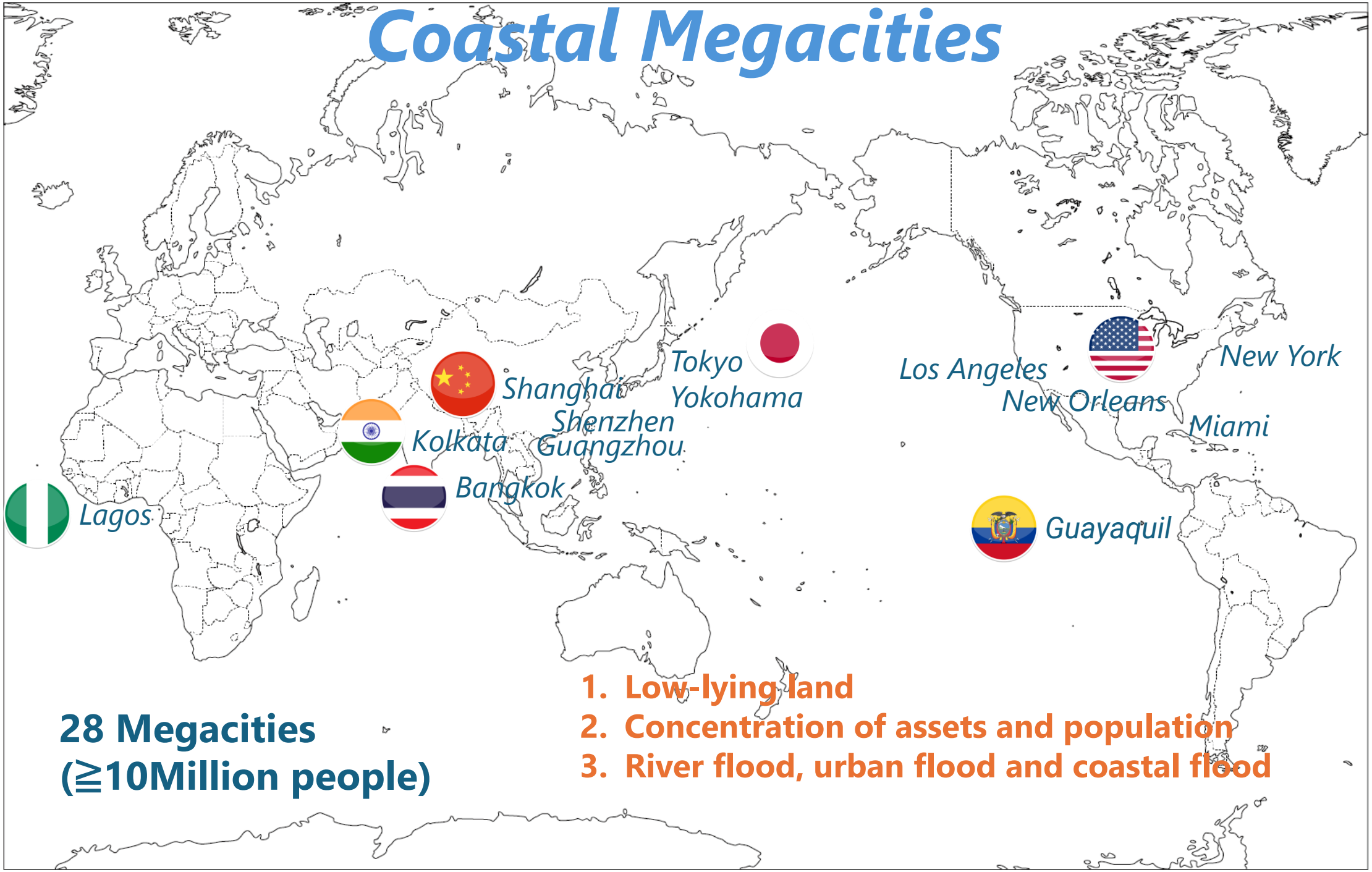
***Taichi Tebakari***

*Professor, Department of Civil and Environmental Engineering*

*Director, Asia Water Science Research Center*

*Chuo University*

# Coastal Megacities




**28 Megacities**
**(≧10Million people)**

1. **Low-lying land**
2. **Concentration of assets and population**
3. **River flood, urban flood and coastal flood**

# Impact of Climate Change in Coastal Megacities

**Sea level rise**

- Submerge
  - Loss of low-lying wetlands and tidal flats
- Coastal erosion
  - Decrease and disappearance of sandy beaches
  - Retreat and disappearance of barrier islands and spit
  - Sea cliff erosion
  - Disappearance of mangroves
  - Disappearance of coral reefs

  → Changes in Fisheries Resources
- Tides and tidal current changes
  - Change in tidal prism
  - Decrease in seawater exchange rate
- **Saltwater intrusion**
  - Saltwater intrusion into lakes and marshes
  - **Saltwater intrusion into rivers and streams**
  - Saltwater intrusion into groundwater
  - Decrease in freshwater lenses
  - Rise in groundwater levels

  → Increased salinity; Formation of density stratification and anoxic layer; Decreased functionality of freshwater intake facilities; Increased salt damage
- Sediment deposition change
  - Cross-sectional change of estuary, estuary blockage

  → Decrease in ground bearing capacity; Increased risk of ground liquefaction; Buried navigation channels
- Decrease in underwater light intensity
  - Changes in plankton growth
  - Loss of seaweed beds

  → Changes in Fisheries Resources

**Typhoon giant and changing path**

- Increase in storm surge
- Increase in waves
  - Increase in water depth and wave height
  - Increase in launch height and wave overtopping
  - Increase in wave power

  → Functional deterioration/damage of coastal protection facilities; Functional deterioration/damage of port facilities; Inundation of waterfront areas; Impact on coastal roads and railroads
- Increase in wind speed
  - Increase in wind pressure

  → Insufficient height under bridge girders; Lack of flood control and water utilization functions of dams

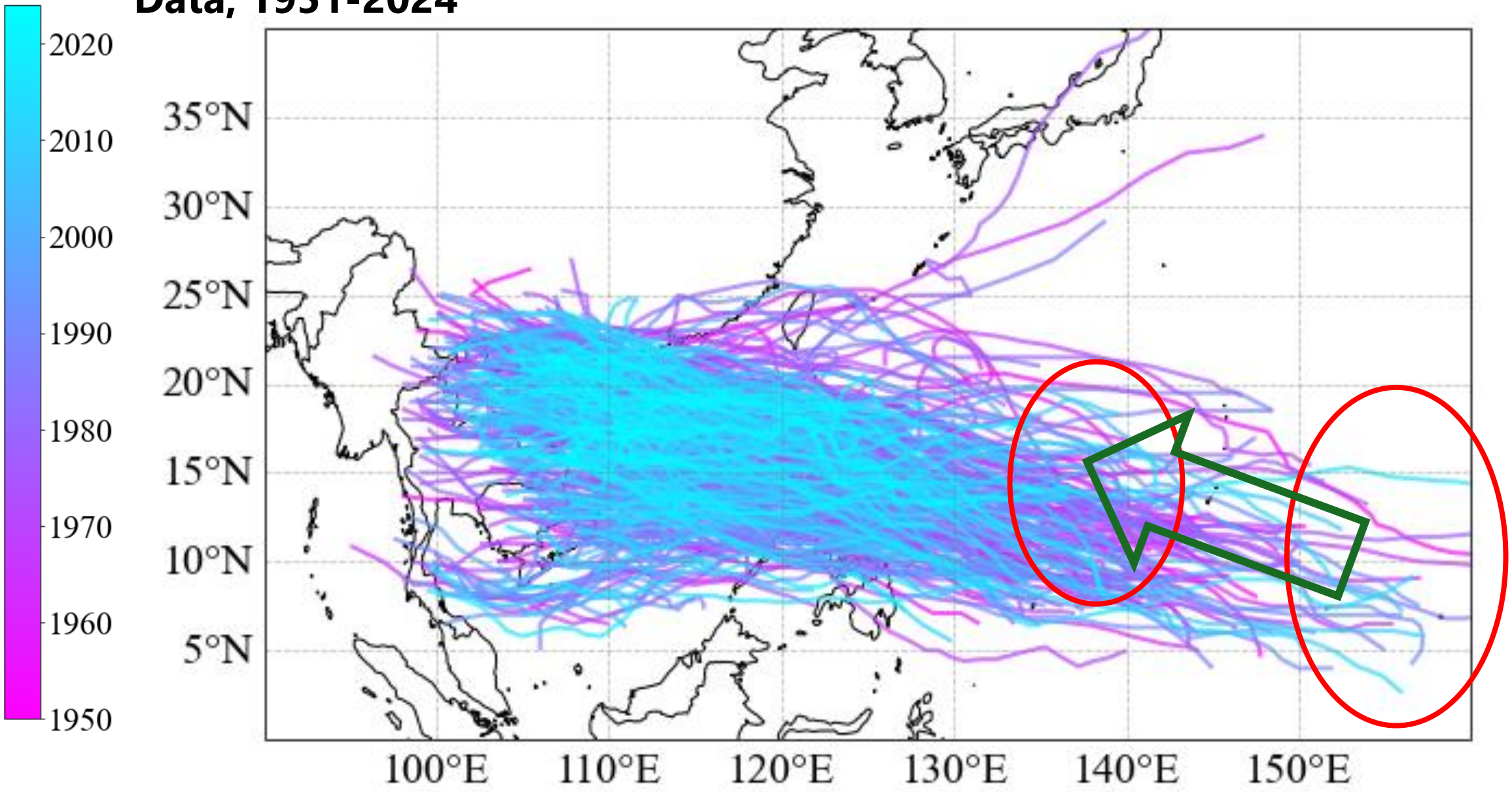
Precipitation change

- Increase in precipitation
  - Increase in flood water level
- Change in precipitation pattern
  - **Increase in urban flood**
  - Decrease in drought flow

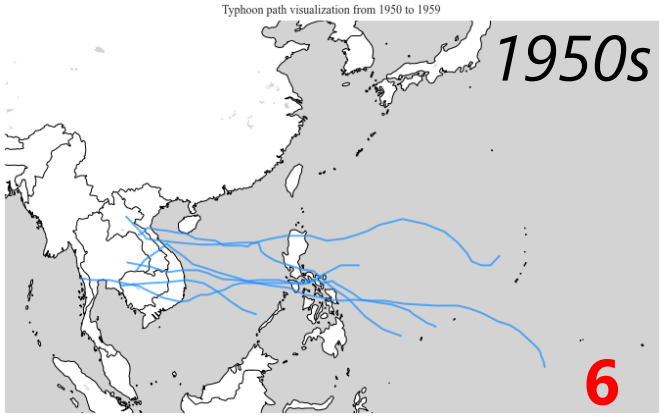
  → Insufficient drainage capacity; Traffic jam; Loss of tourism opportunities

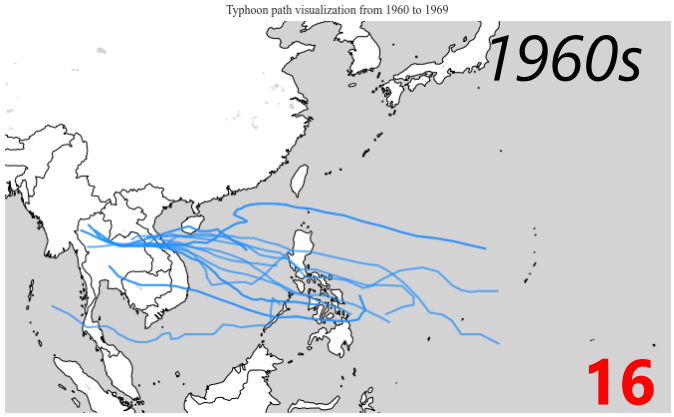
# Typhoons Striking the Indochina Peninsula

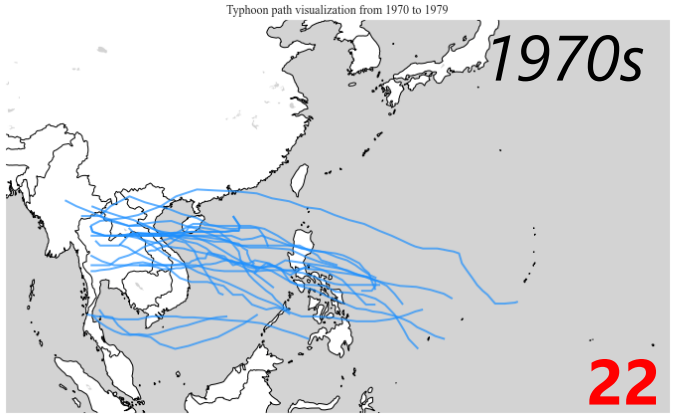
**Data; 1951-2024**

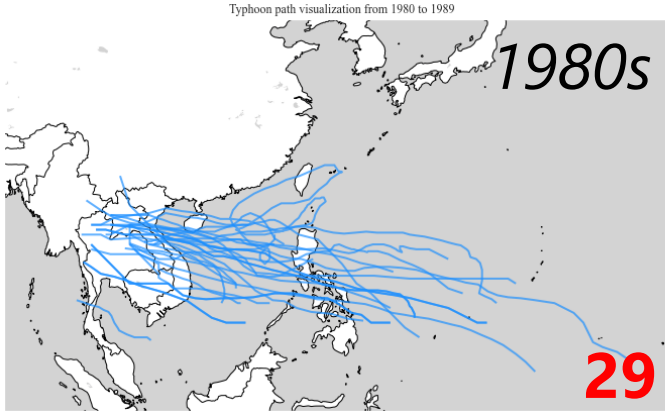


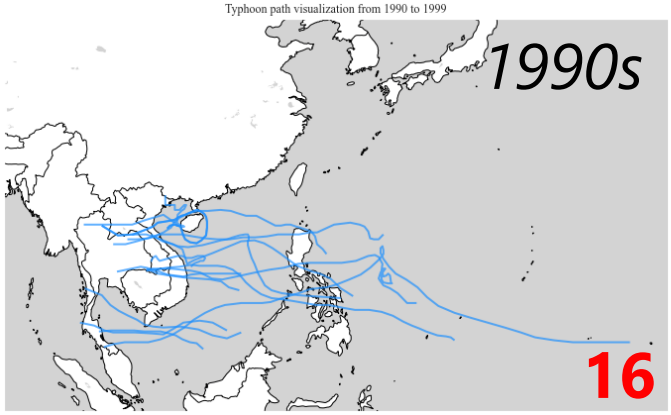
# Typhoon Strikes Thailand

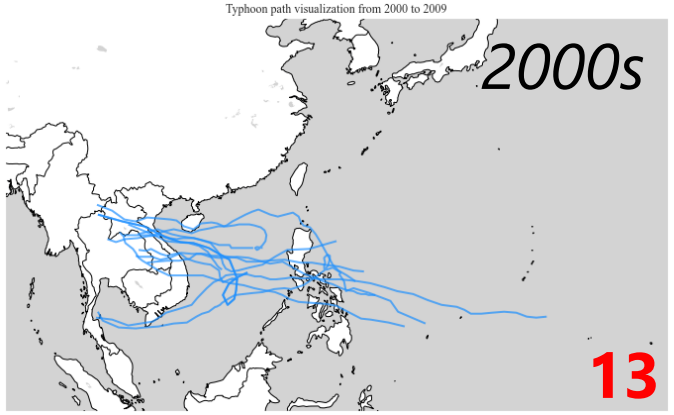


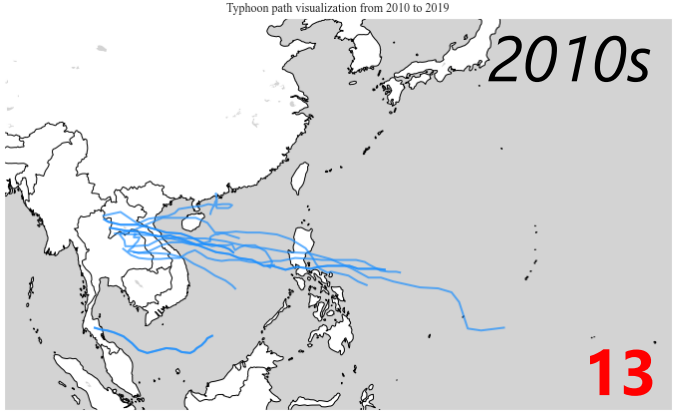



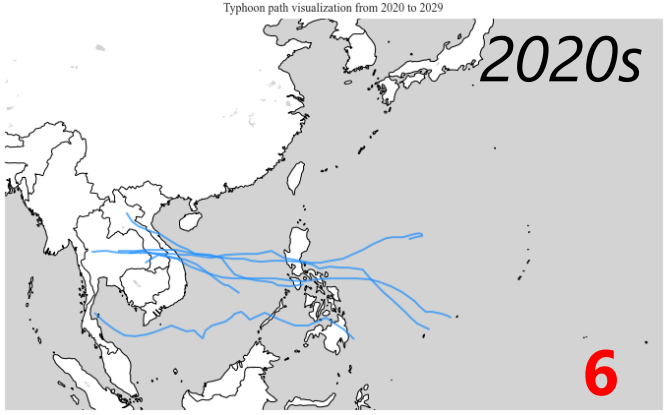



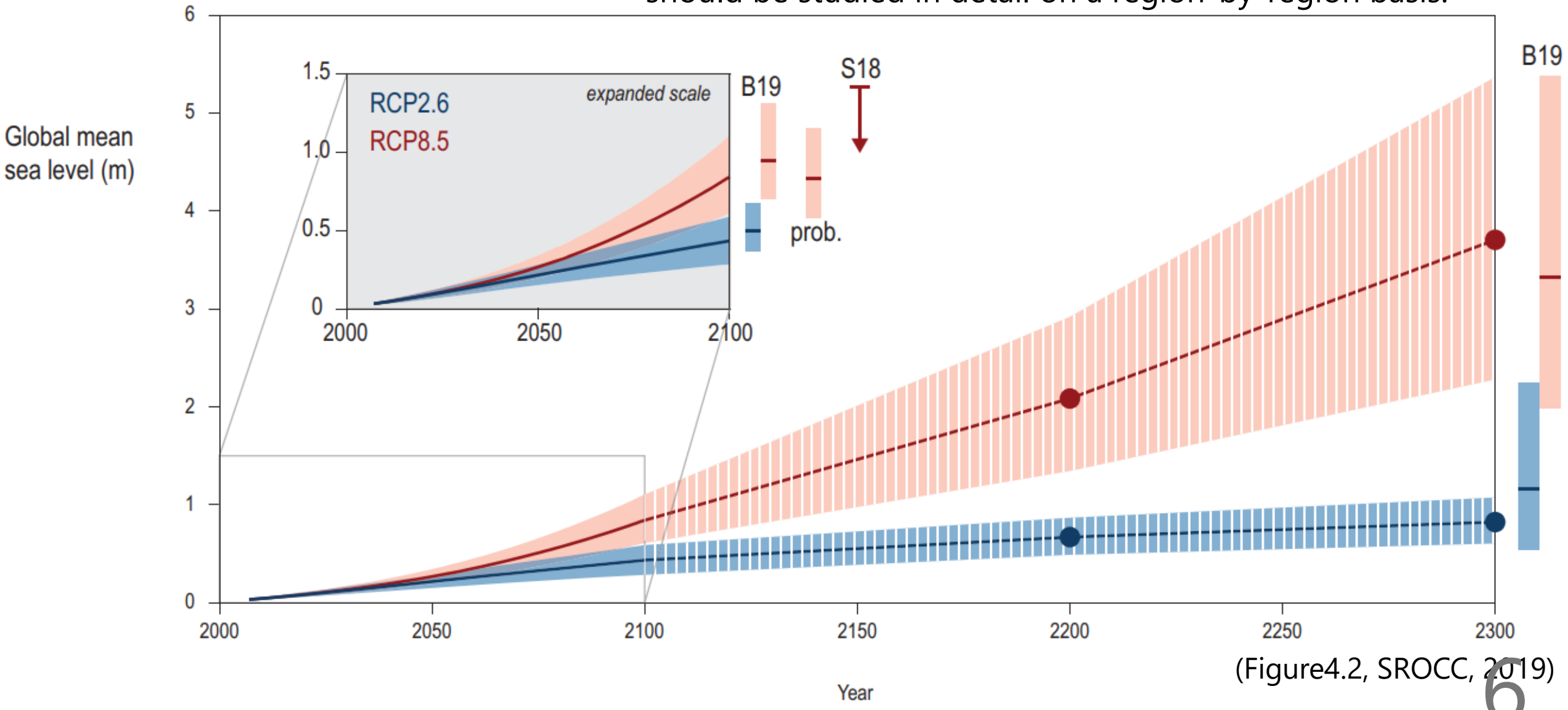




- There is NO statistically significant increase or decrease in the number and intensity of typhoons.
- However, the impact of typhoons hitting the Indochina Peninsula requires close monitoring.

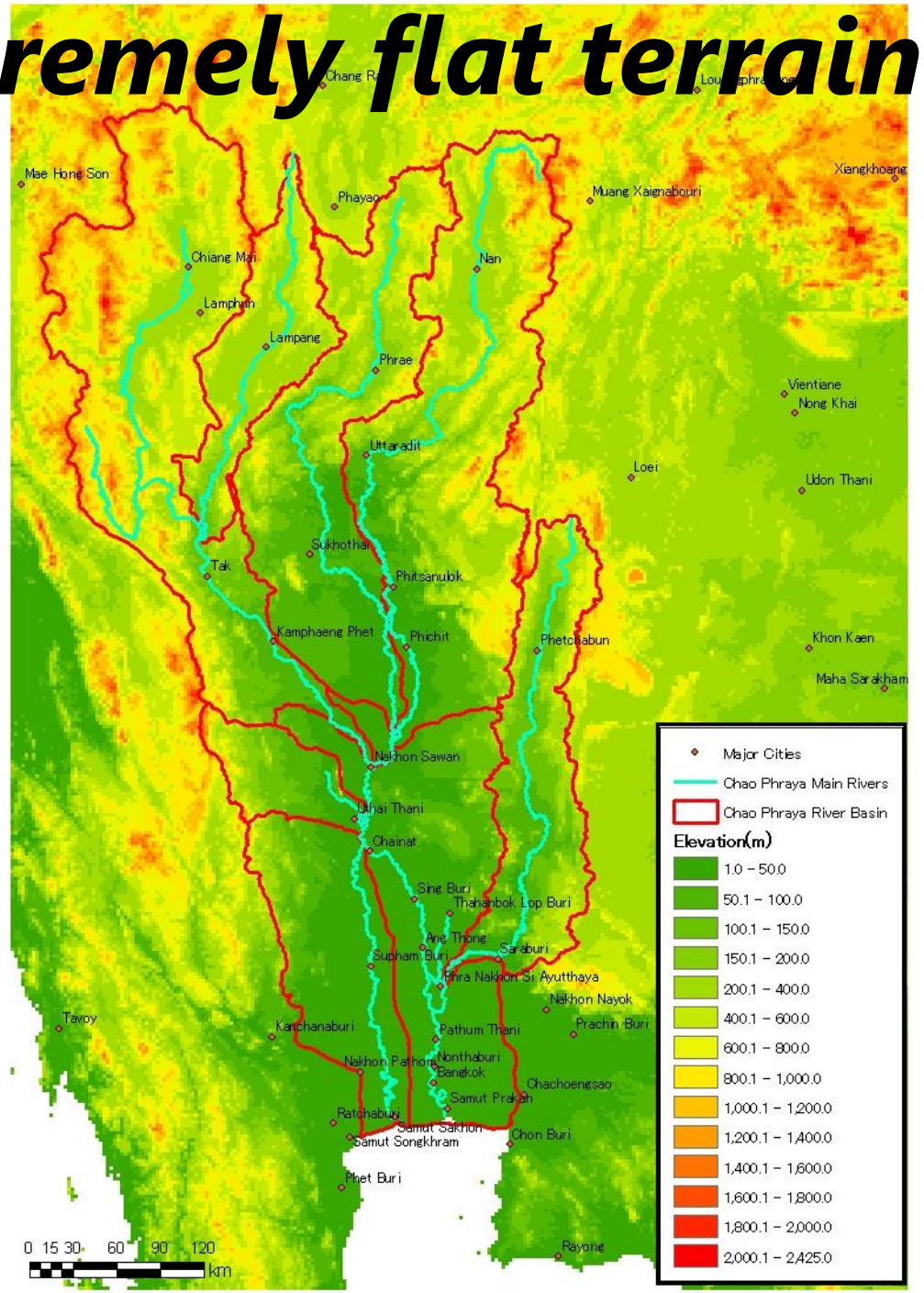
# Sea level rise

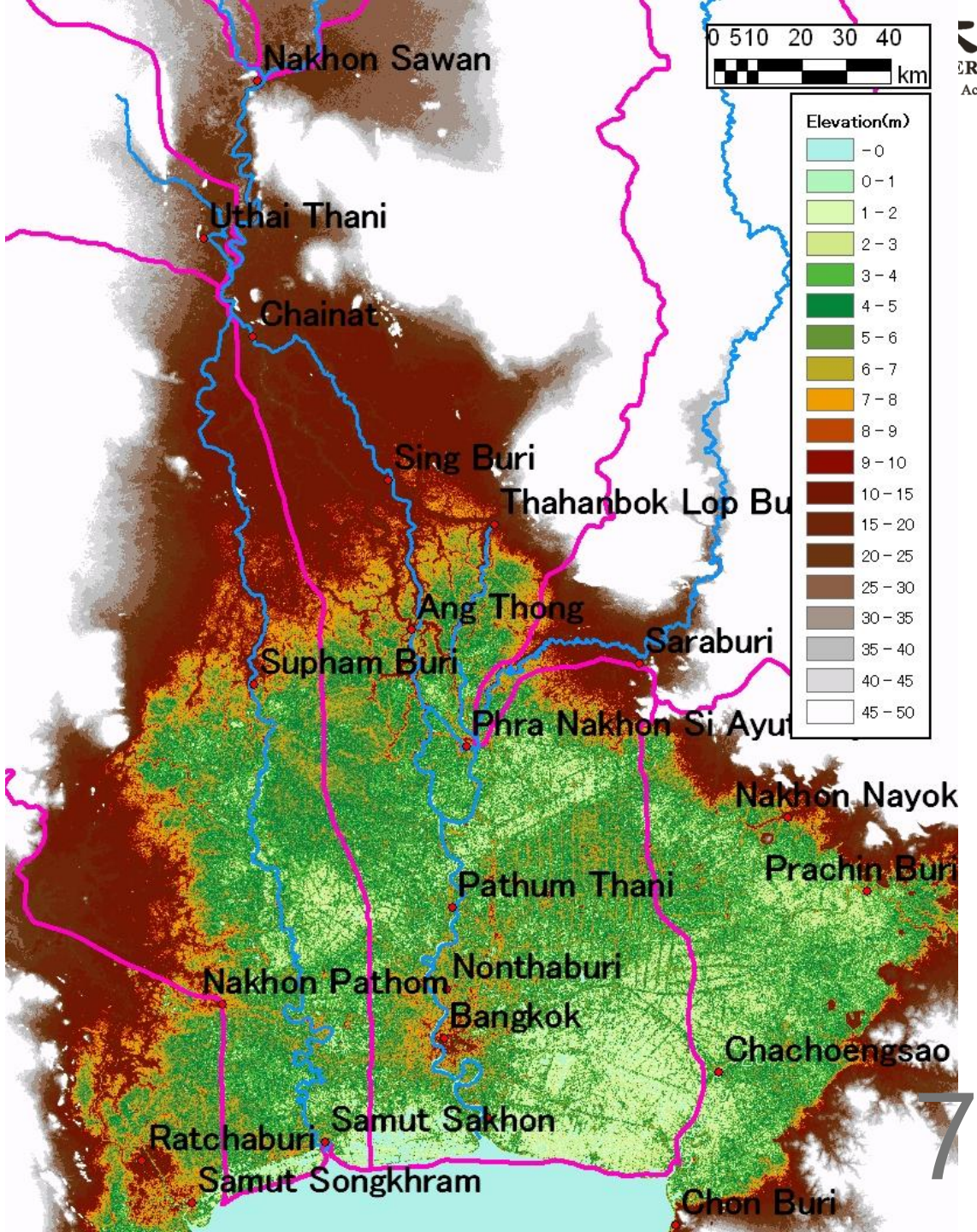
Tide levels have inherent regional characteristics and should be studied in detail on a region-by-region basis.

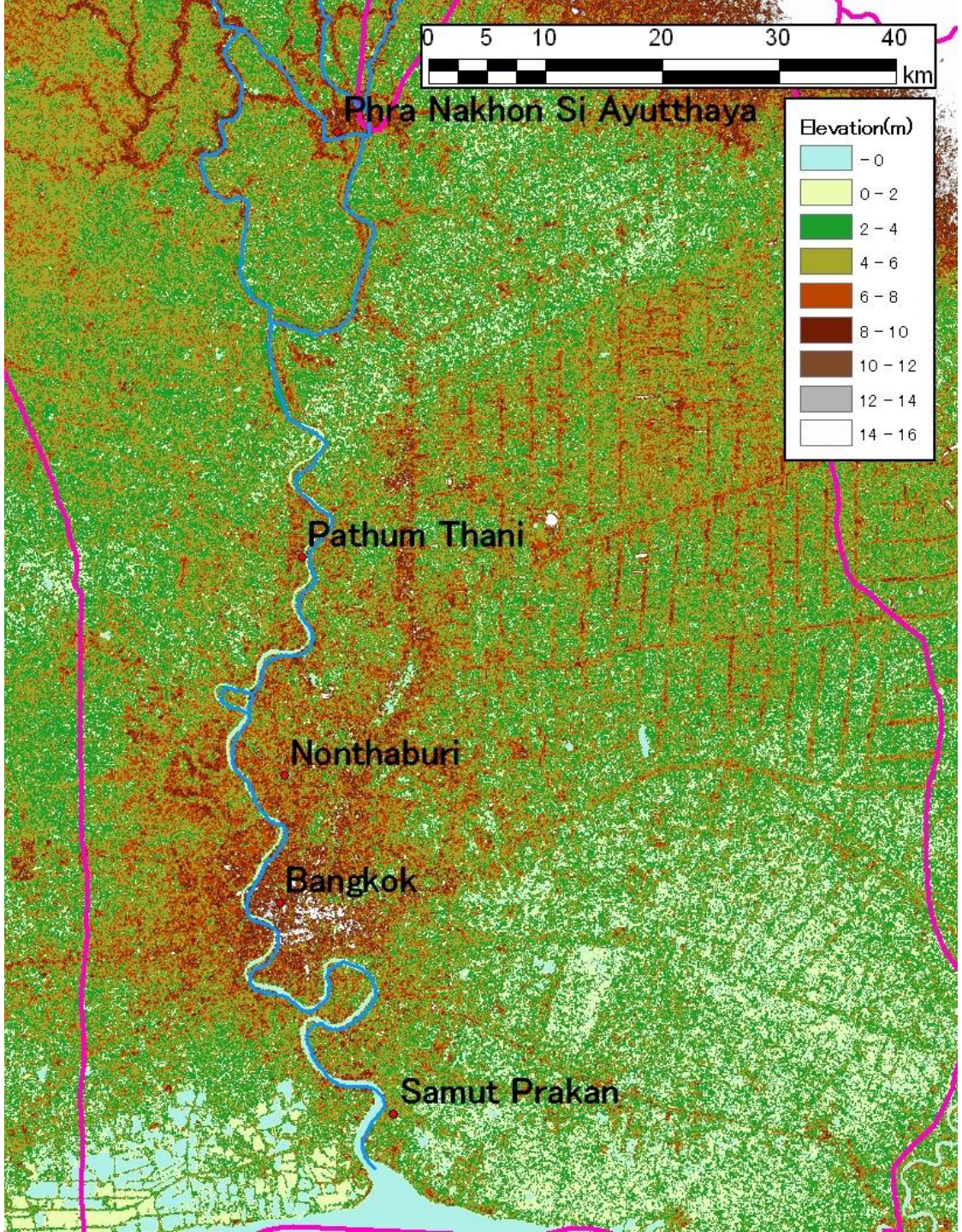


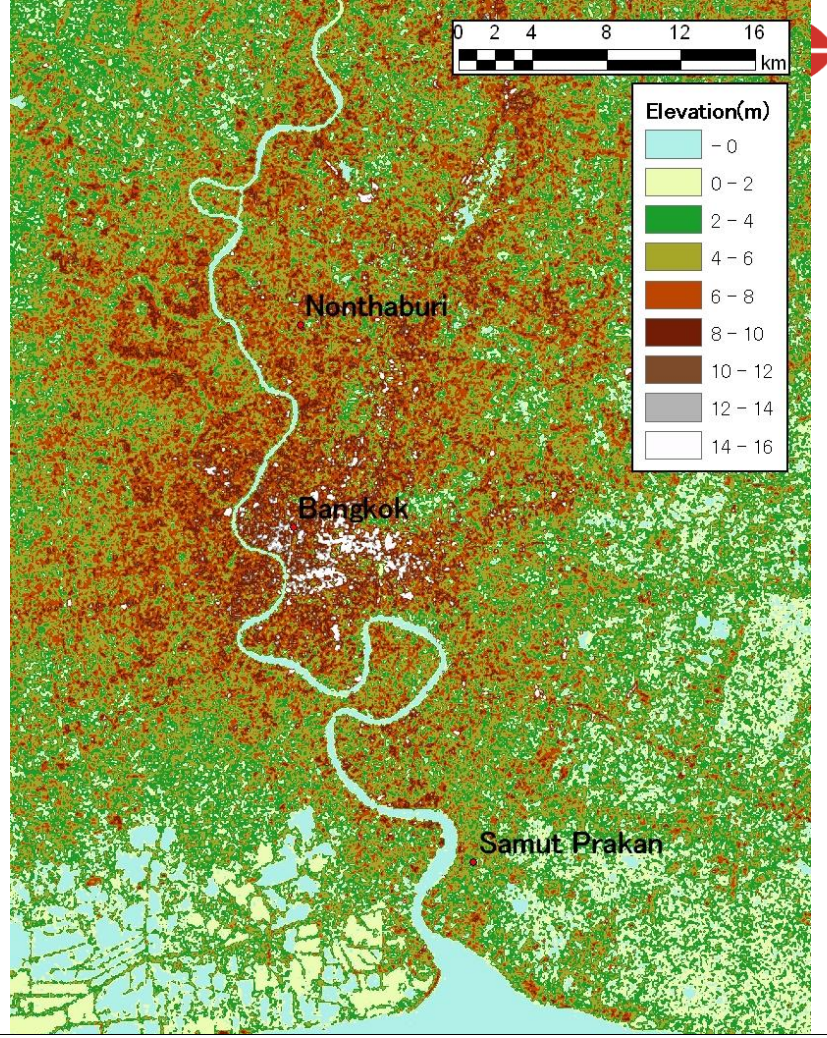

(Figure4.2, SROCC, 2019)

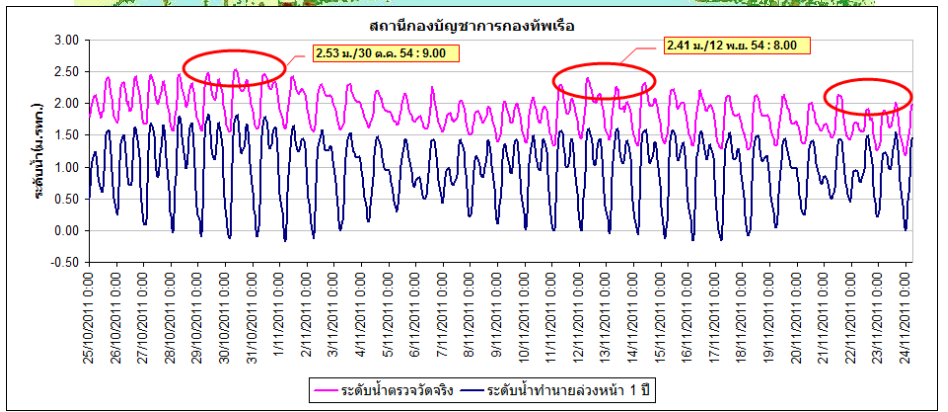
# Extremely flat terrain




0 5 10 20 30 40
km
Elevation(m)
- 0
0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
Phra Nakhon Si Ayutthaya
Pathum Thani
Nonthaburi
Bangkok
Samut Prakan


0 2 4 8 12 16
km
Elevation(m)
- 0
0 - 2
2 - 4
4 - 6
6 - 8
8 - 10
10 - 12
12 - 14
14 - 16
Nonthaburi
Bangkok
Samut Prakan


สถานีกองบัญชาการกองทัพเรือ
2.53 ม./30 ต.ค. 54 : 9.00
2.41 ม./12 พ.ย. 54 : 8.00
ระดับน้ำ(ม.รทก.)
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2.50
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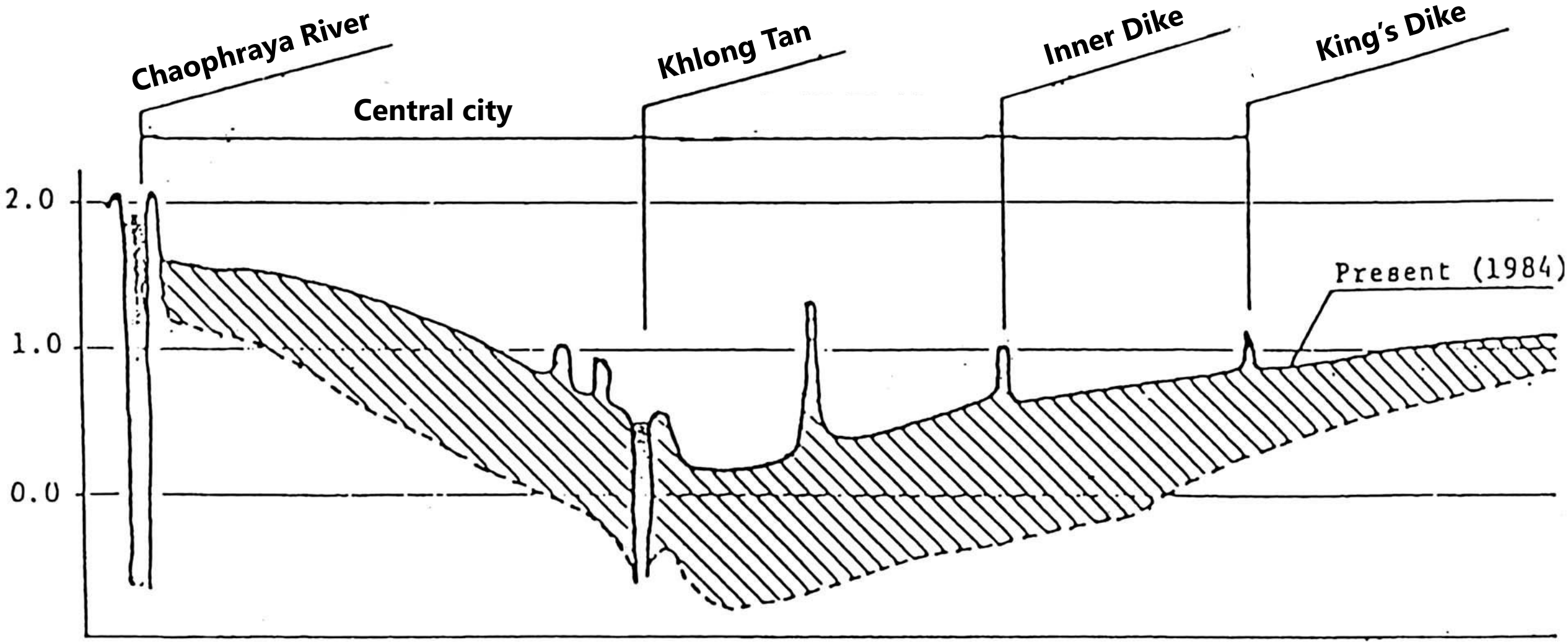
24/11/2011 0:00
ระดับน้ำตรวจวัดจริง
ระดับน้ำทำนายล่วงหน้า 1 ปี

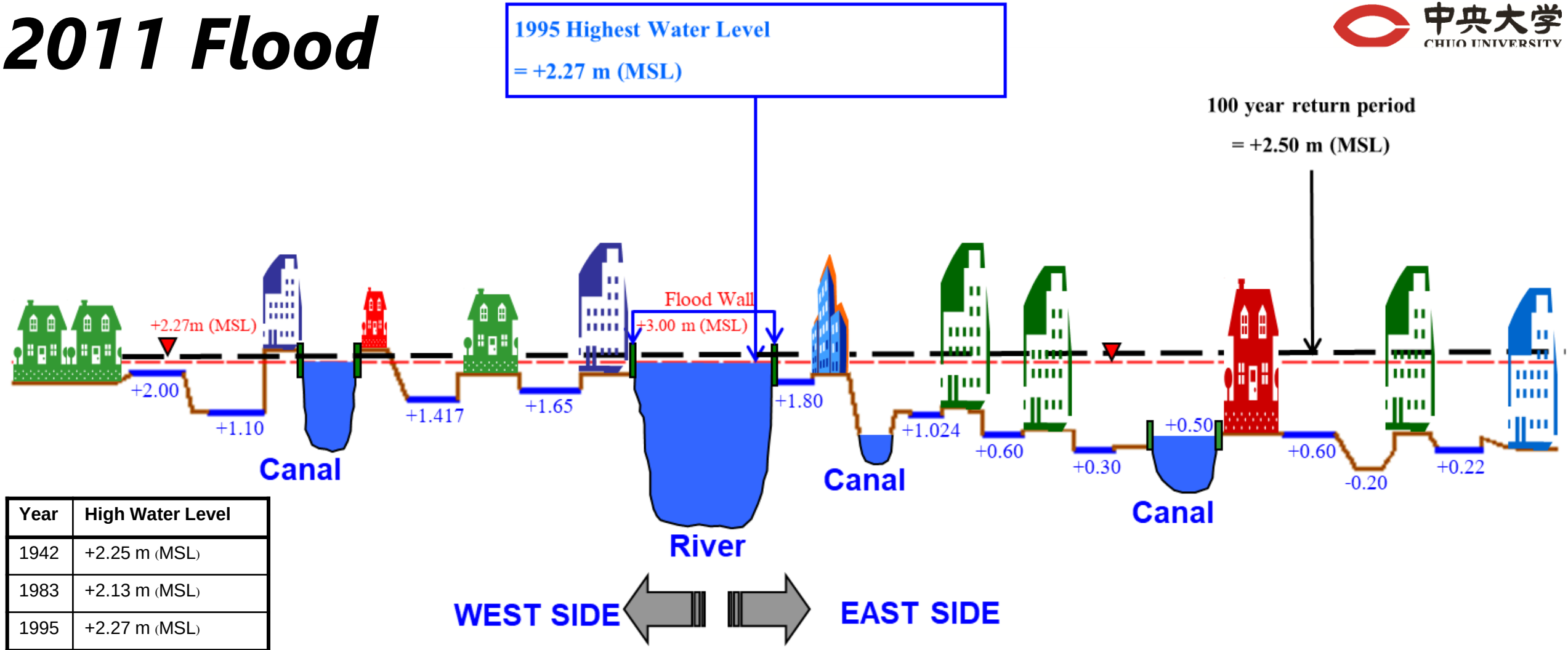
# Cross-sectional view of Bangkok city






(Yanagi, 1996)

# 2011 Flood




| Year | High Water Level |
|---|---|
| 1942 | +2.25 m (MSL) |
| 1983 | +2.13 m (MSL) |
| 1995 | +2.27 m (MSL) |
| 1996 | +2.14 m (MSL) |
| 2002 | +2.10 m (MSL) |
| 2006 | +2.22 m (MSL) |
| 2008 | +2.17 m (MSL) |
| 2010 | +2.10 m (MSL) |
| 2011 | +2.53 m (MSL) |

Not only flood waters from upstream, but also tidal currents caused extensive inundation damage.

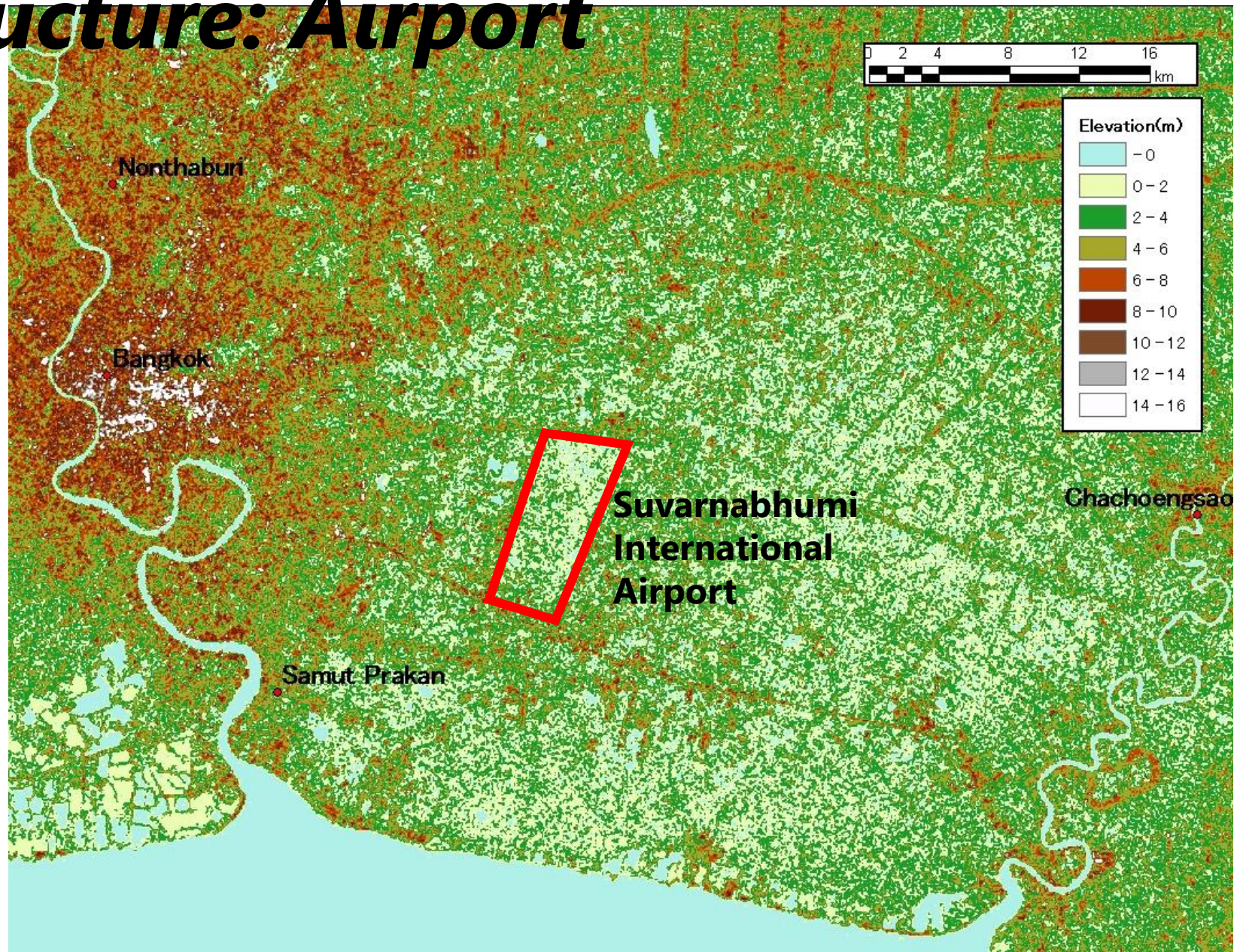
# 2011 Flood in Bangkok



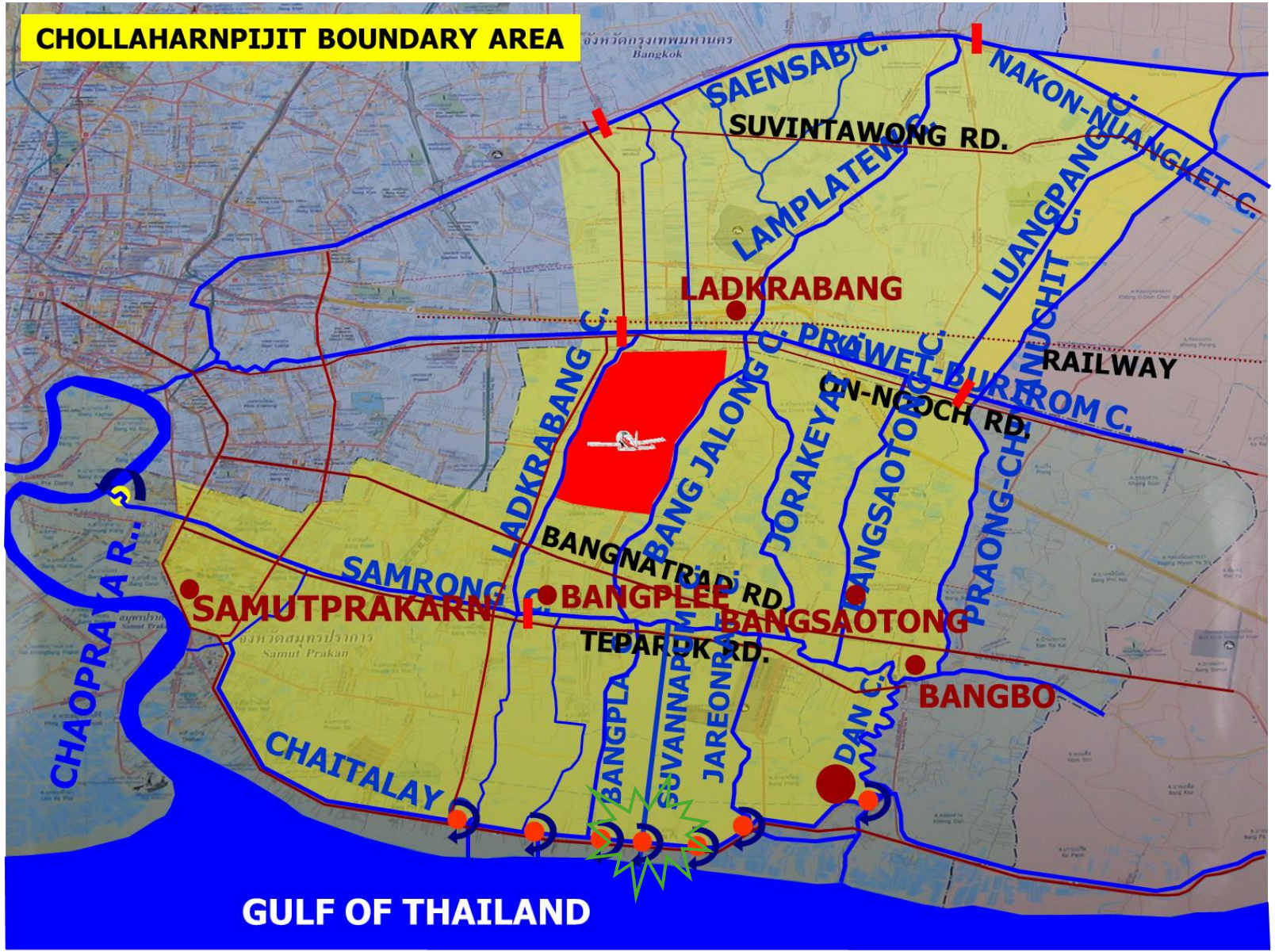





# Flood risk and countermeasures for critical infrastructure: Airport



# *Flood risk and countermeasures for critical infrastructure: Airport*



# Flood risk and countermeasures for critical infrastructure: Airport


# *Flood risk and countermeasures for critical infrastructure: Water filtration plant*

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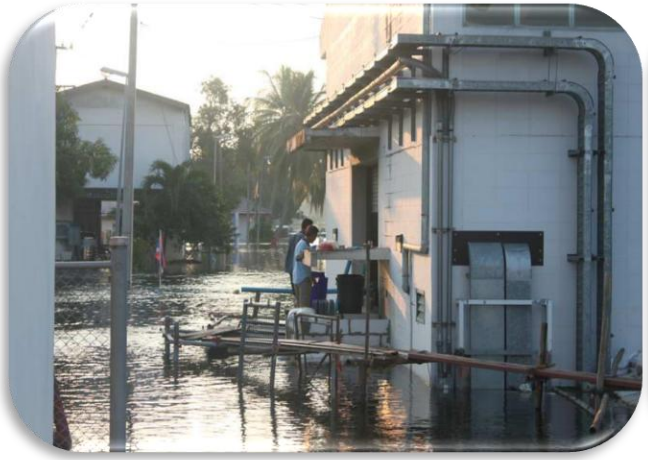
2011 Flood



# *Use of high-resolution elevation data to assess the vulnerability of the Bangkok metropolitan area to sea level rise*

Kingdom of Thailand
Ministry of Agriculture and Cooperatives
Royal Irrigation Department

**PROJECT FOR COMPREHENSIVE FLOOD MANAGEMENT PLAN FOR THE CHAO PHRAYA RIVER BASIN (SUB-COMPONENT 1-1 AERIAL SURVEY BY LIDAR)**

**FINAL REPORT**

**August 2012**

**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

**PASCO CORPORATION**
**KOKUSAI KOGYO CO., LTD.**
**ASIA AIR SURVEY CO., LTD.**

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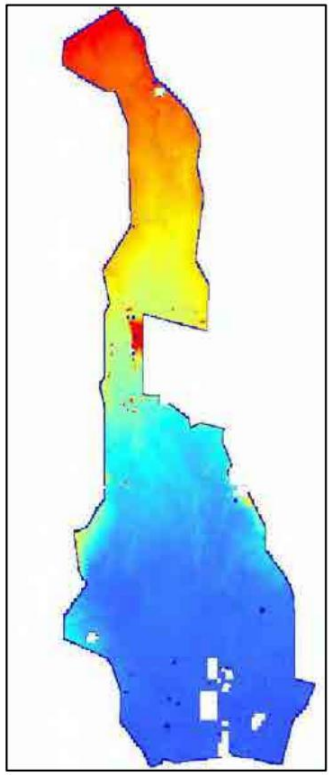
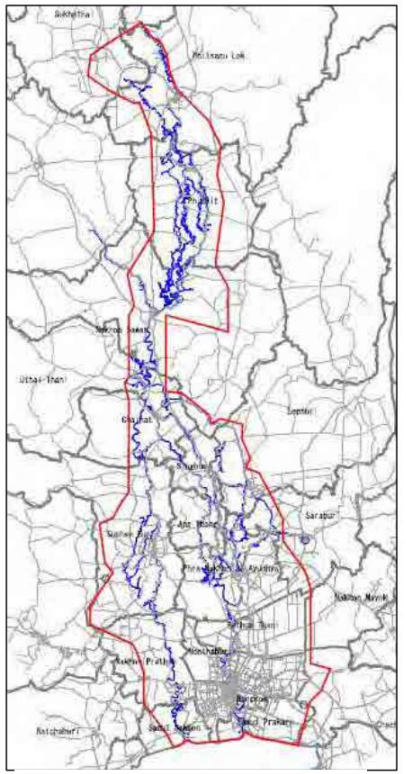
|---|
| JR |
| 12-119 |

This Work shall be performed to examine the possibility of allowing a certain amount of flooding with a focus on controlling overflowing of the river into farmland area for the region that was affected by the flood that occurred in 2011. In order to determine the feasibility and formulate plans, detailed topographic data of the flooded region needs to be utilized. However, topographic map data that can currently be used has an accuracy of 2 meters in the difference of elevation, which is the region that was affected by the flood that occurred in 2011.

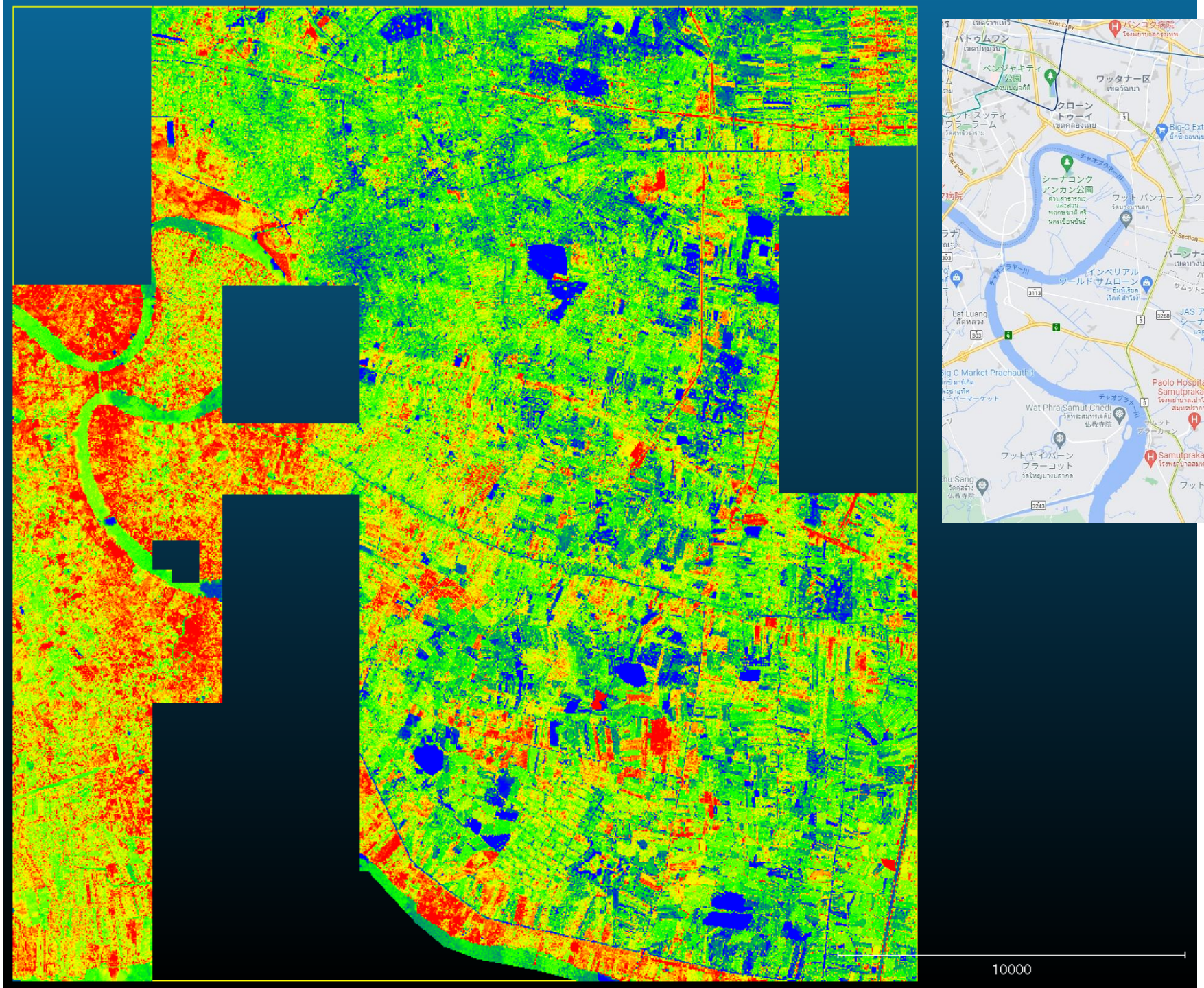


Location of the survey work



Target area of the work

In order to determine the feasibility and formulate plans, detailed topographic data of the flooded region needs to be utilized. However, topographic map data that can currently be used has **an accuracy of 2 meters** in the difference of elevation, which is inadequate for the evaluation of suitable areas in the mid and lower portions of the flat Chao Phraya River, necessitating the creation of new detailed topographic data by means of airborne laser scanning.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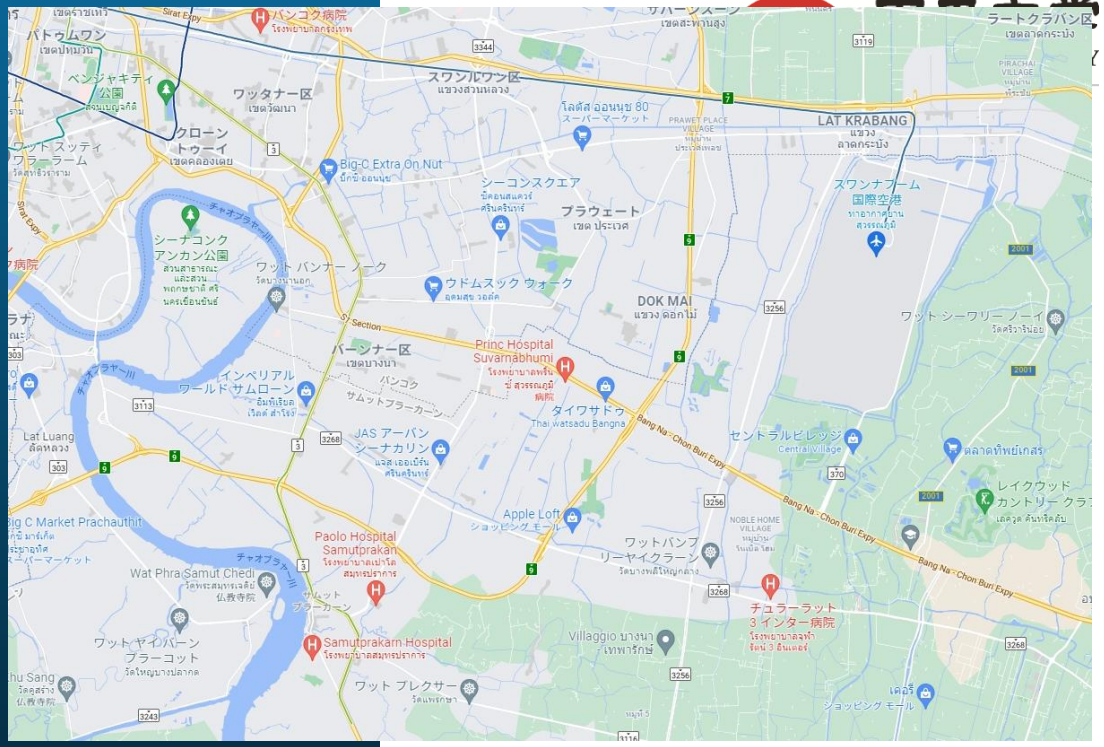
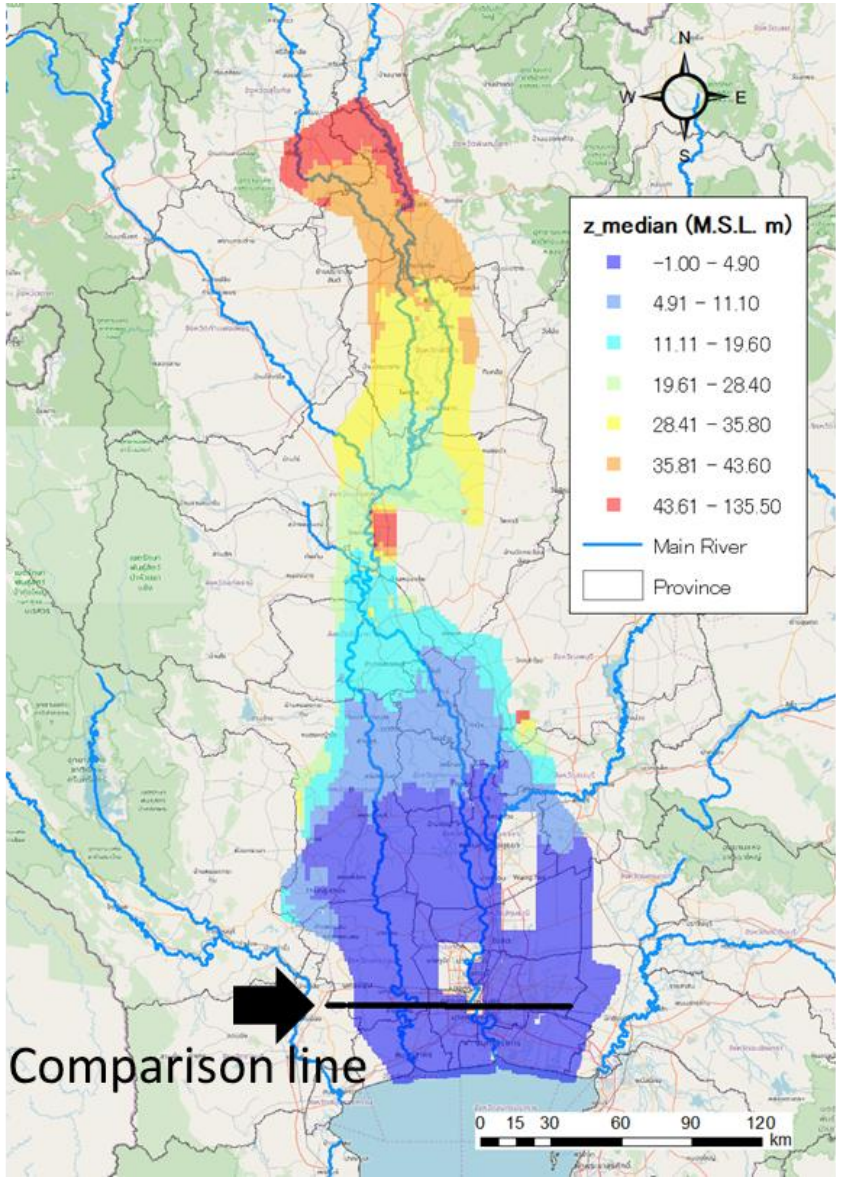
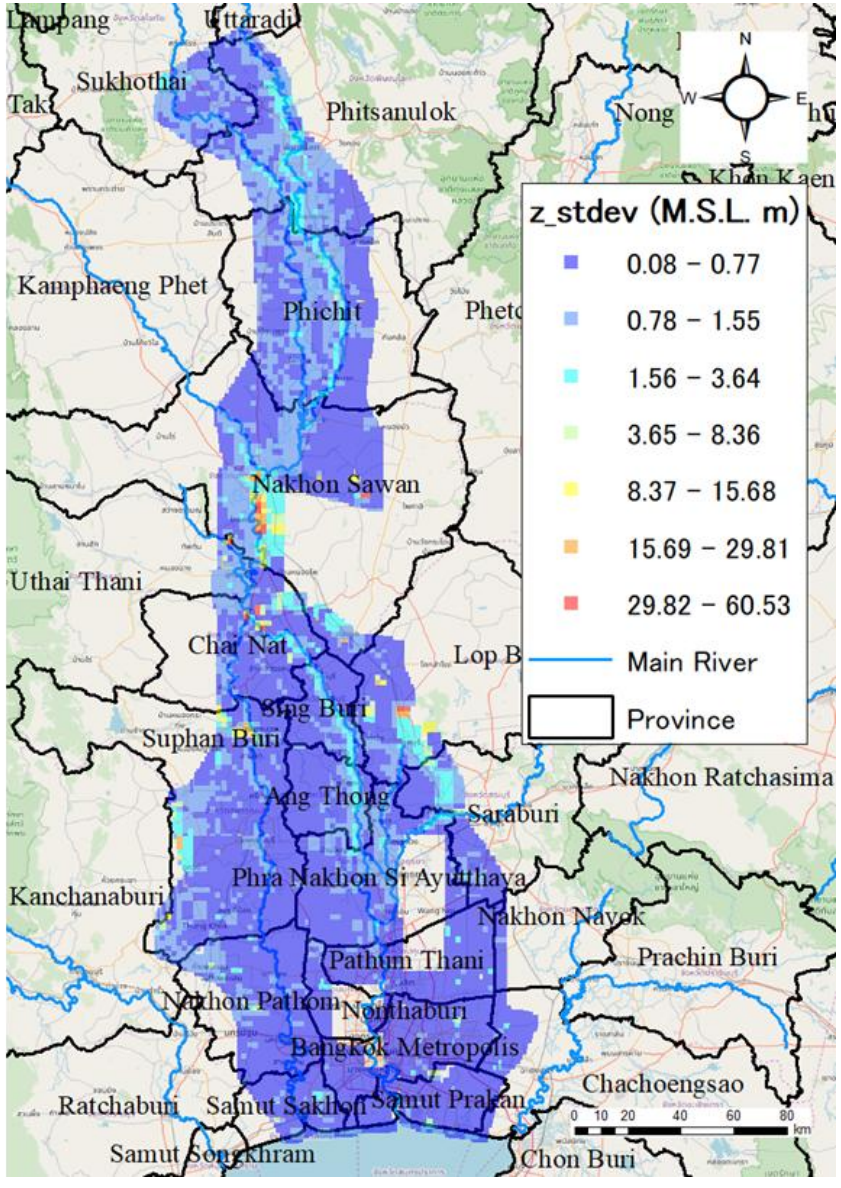
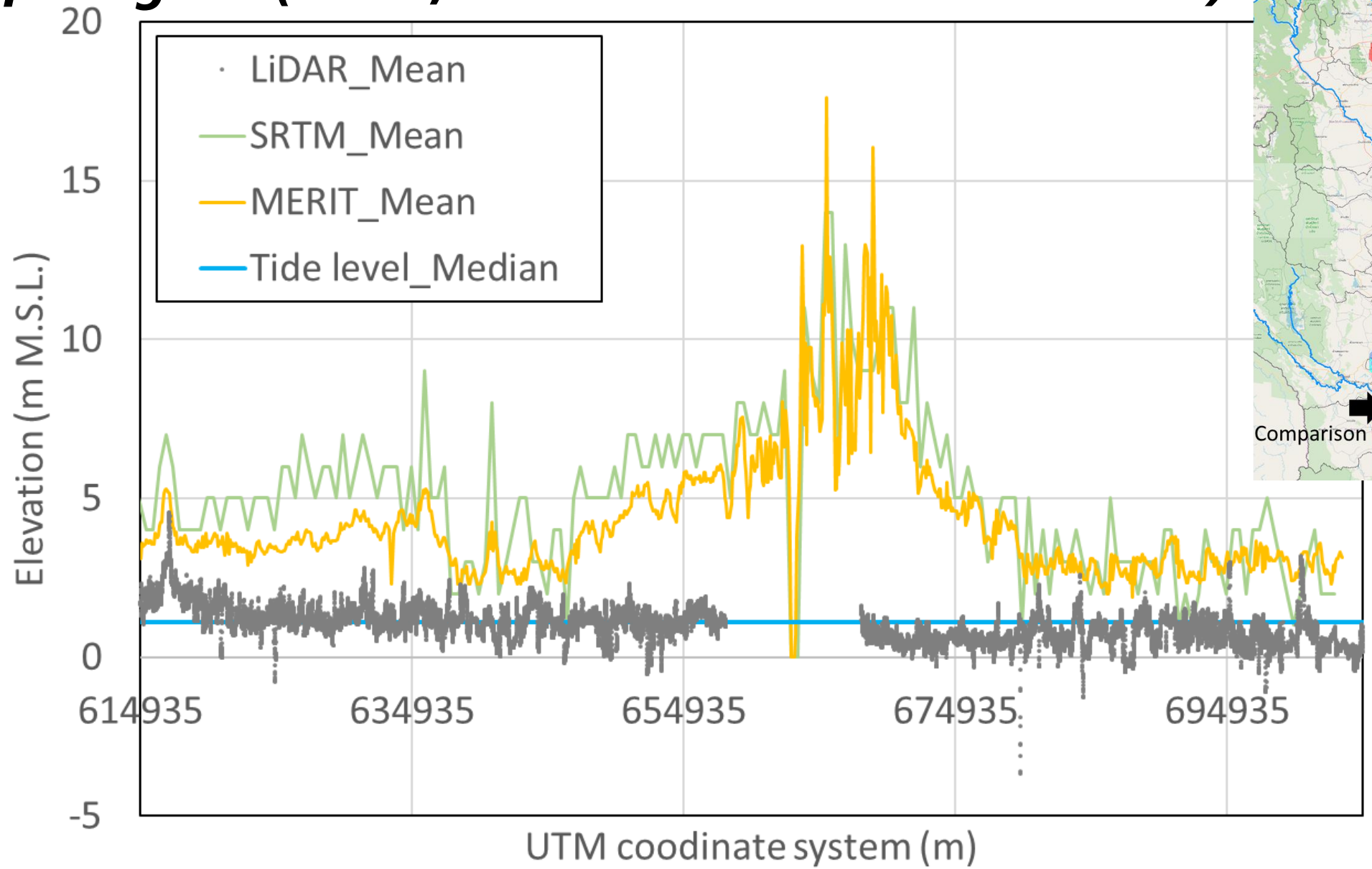

バンコク病院
バトゥムワン
ベンジャキティ公園
ワッタナー区
クローントゥーイ
Big-C Extra On Nut
スワンルワン区
LAT KRABANG
シーナコンクアンカン公園
シーコンスクエア
プラウェート
スワンナプーム国際空港
ワット バンナー ノーク
ウドムスック ウォーク
DOK MAI
バーンナー区
Princ Hospital Suvarnabhumi
インペリアルワールド サムローン
ダイワサドゥ
JAS アーバンシーナカリン
セントラルビレッジ
Lat Luang
Apple Loft
Paolo Hospital Samutprakan
ワットバンプリーヤイクラーン
Wat Phra Samut Chedi
チュラーラット3インター病院
Samutprakarn Hospital
Villaggio บางนา
ワット プレクサー

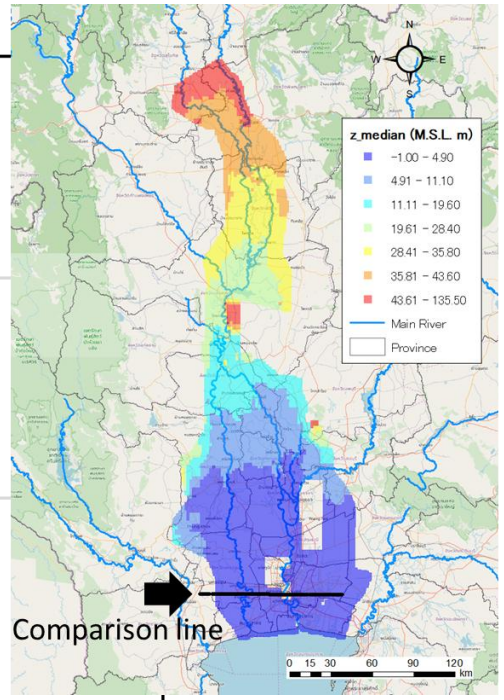
# *Distribution maps of the median and standard deviation of LiDAR elevation data (AMSL; altitude above mean sea level, z_median; median value in a 2 km × 2km mesh, z_stdev; standard deviation in a 2 km × 2km mesh)*



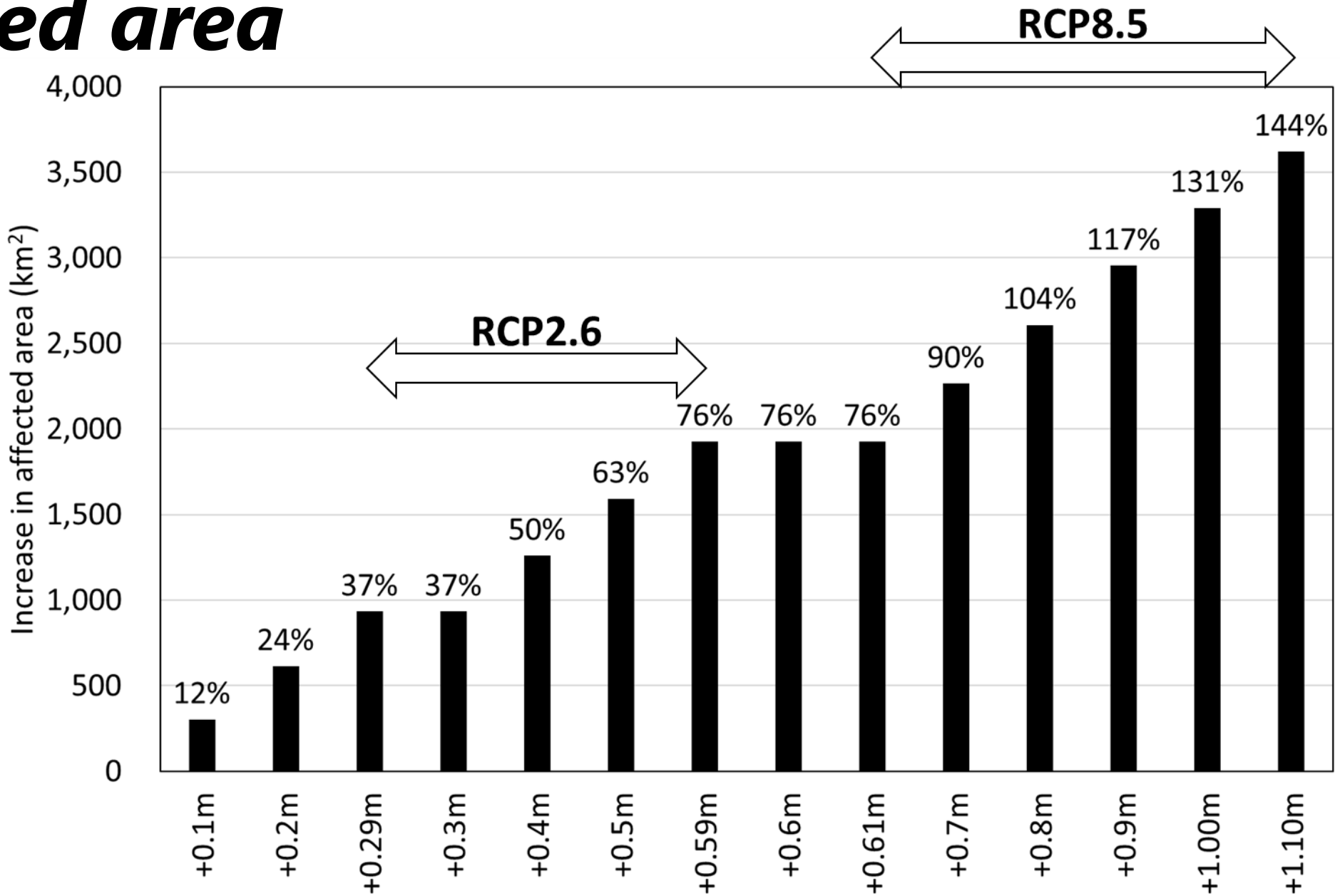



# *LiDAR, SRTM and MERIT elevation data, from East to West across the center of Bangkok (AMSL; altitude above mean sea level)*

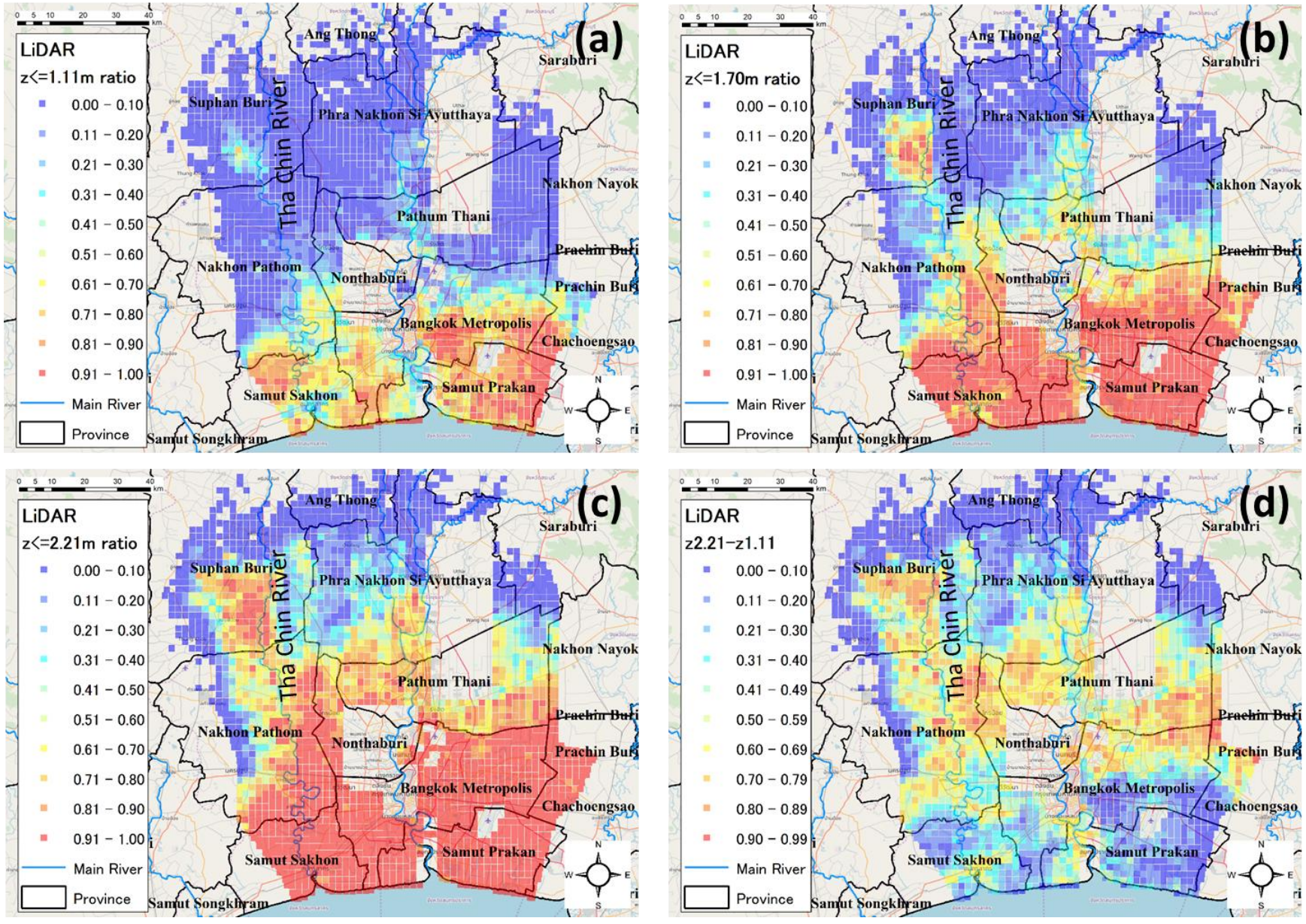


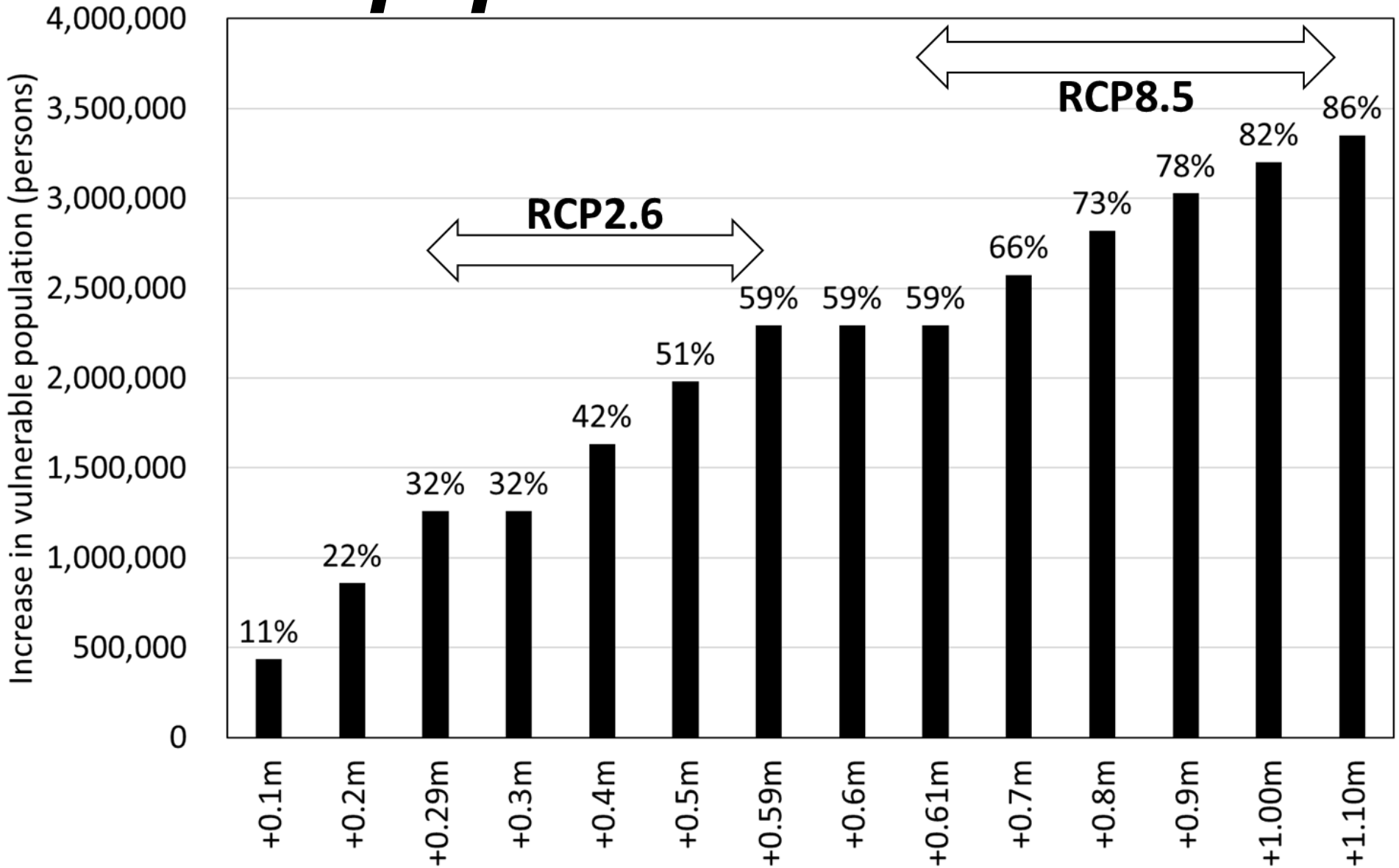
# Sea level change and associated increases in affected area



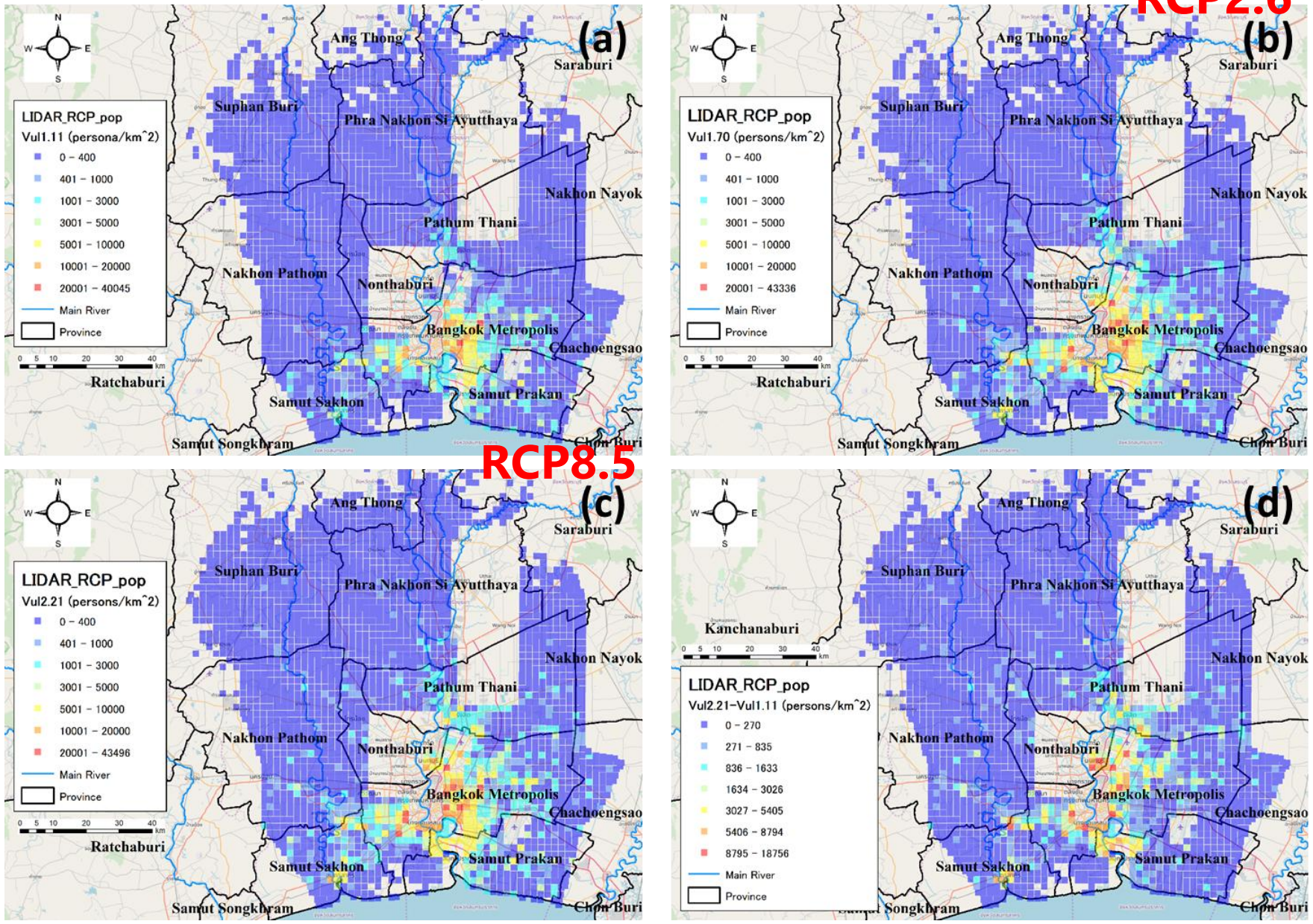
***Distribution maps showing the proportion of area at elevations of (a) ≤ 1.11 m (current mean tide level), (b) ≤ 1.70 m (the worst case scenario for Representative Concentration Pathway [RCP] 2.6), and (c) ≤ 2.21 m (the worst case scenario for RCP8.5). (d) Relative increases from (a) to (c).***



# Sea level change and associated increases in the vulnerable population

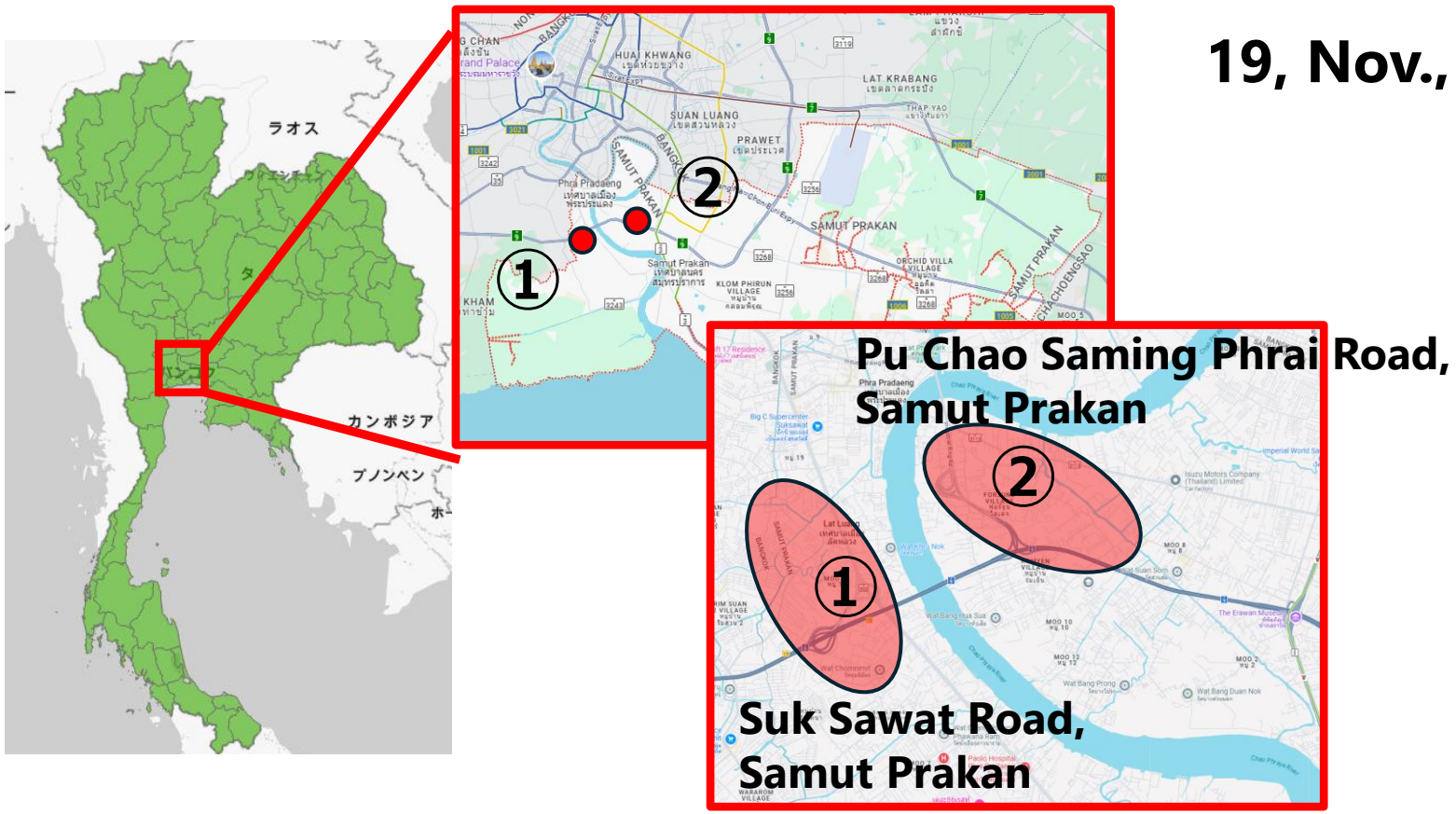


***Distribution maps of vulnerable population density at elevations of (a) ≤ 1.11 m (current median tide level), (b) ≤ 1.70 m (worst case for RCP2.6), and (c) ≤ 2.21 m (worst case for RCP8.5). (d) Increases in vulnerable population density from (a) to (c).***



# Coastal flood due to high tide

Mr. Sakabe




**19, Nov., 2024**

https://www.facebook.com/share/p/16wvF3uCcL/
https://www.facebook.com/share/p/128KetUCG32/

# Coastal flood due to high tide

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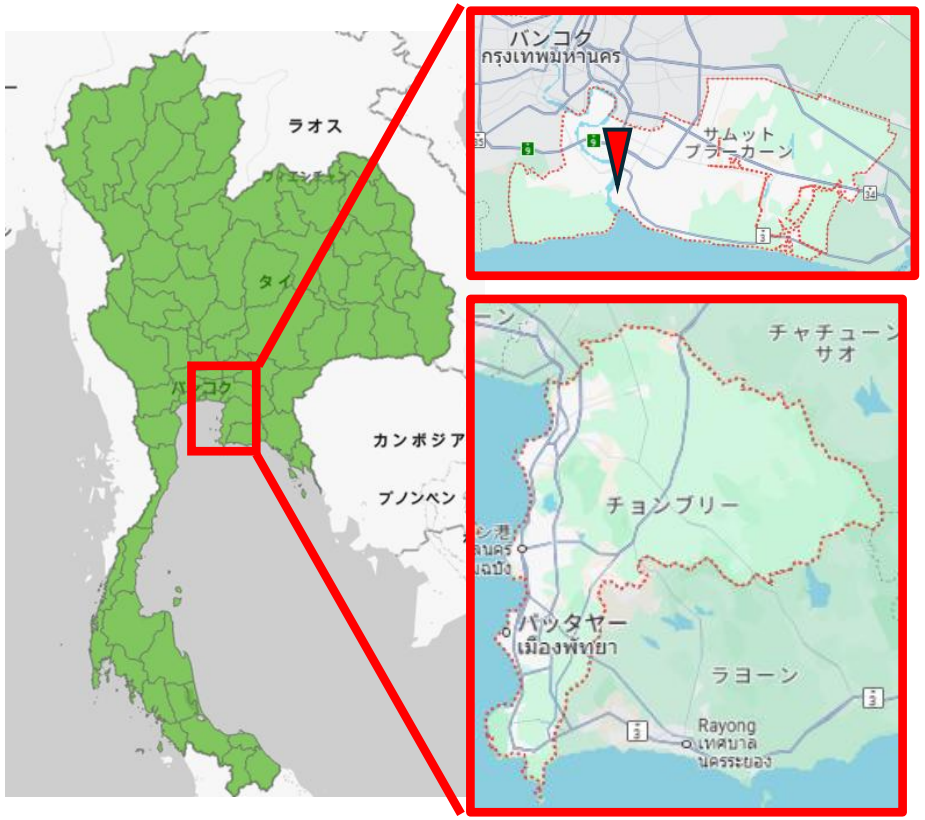
## 17, Dec., 2024




## Pak Nam Market

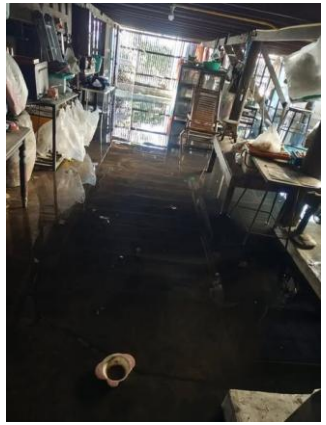

## Coastal road, Chonburi

https://www.facebook.com/js100radio/posts/pfbid02282DWuJQ3VkgScbE1wvaEYFAnXuK9od2LanKDrnmJ4ui65stFizCsJJkmQAvGNZNl?rdid=nZJXlaY4RgU6OoJy

# Seawater intrusion due to sluice gate failure



**13, Jan., 2025**
**Pak Nam, Samut Prakan**

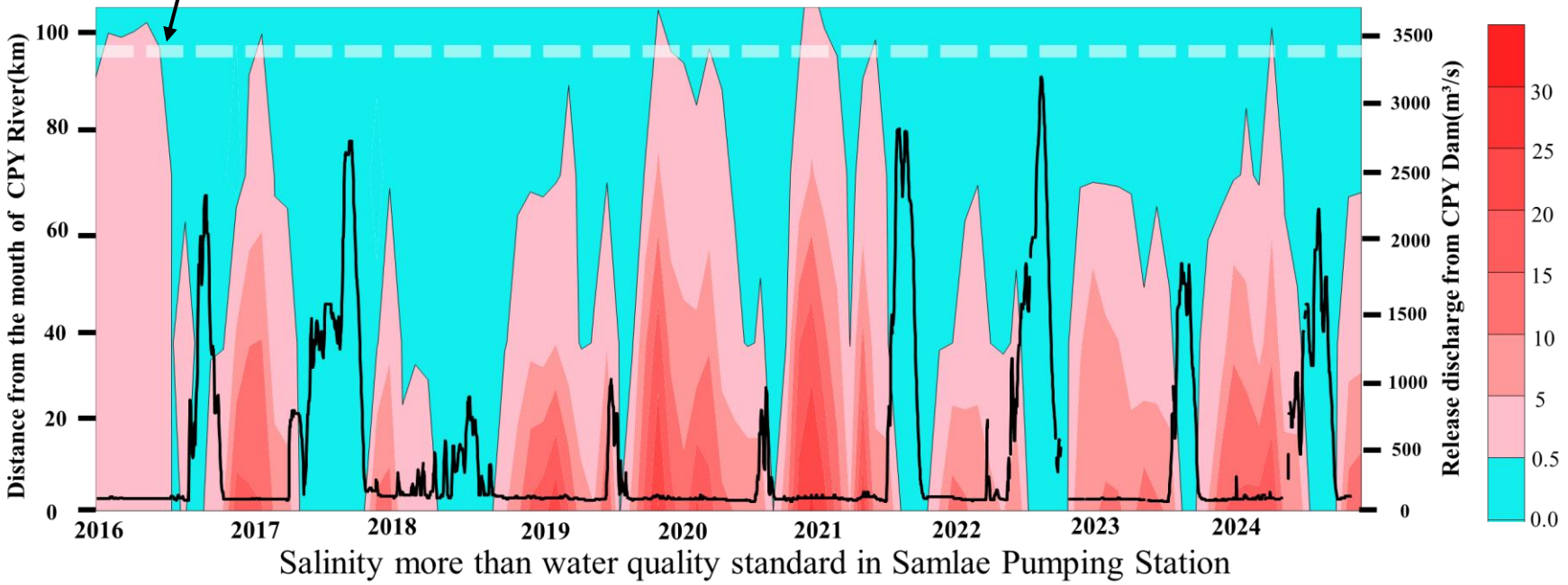


https://www.facebook.com/js100radio/posts/pfbid0E2aNjUFkpQEpoDmsJfCb91MZh5DwJATXHTd4UbtenzUsWuWyPepaRS6ZP52MMdJal

# Saltwater intrusion attacked water resources in Bangkok

**Samlae pumping station:**

Approximately **73%** of raw water in the Bangkok metropolitan area

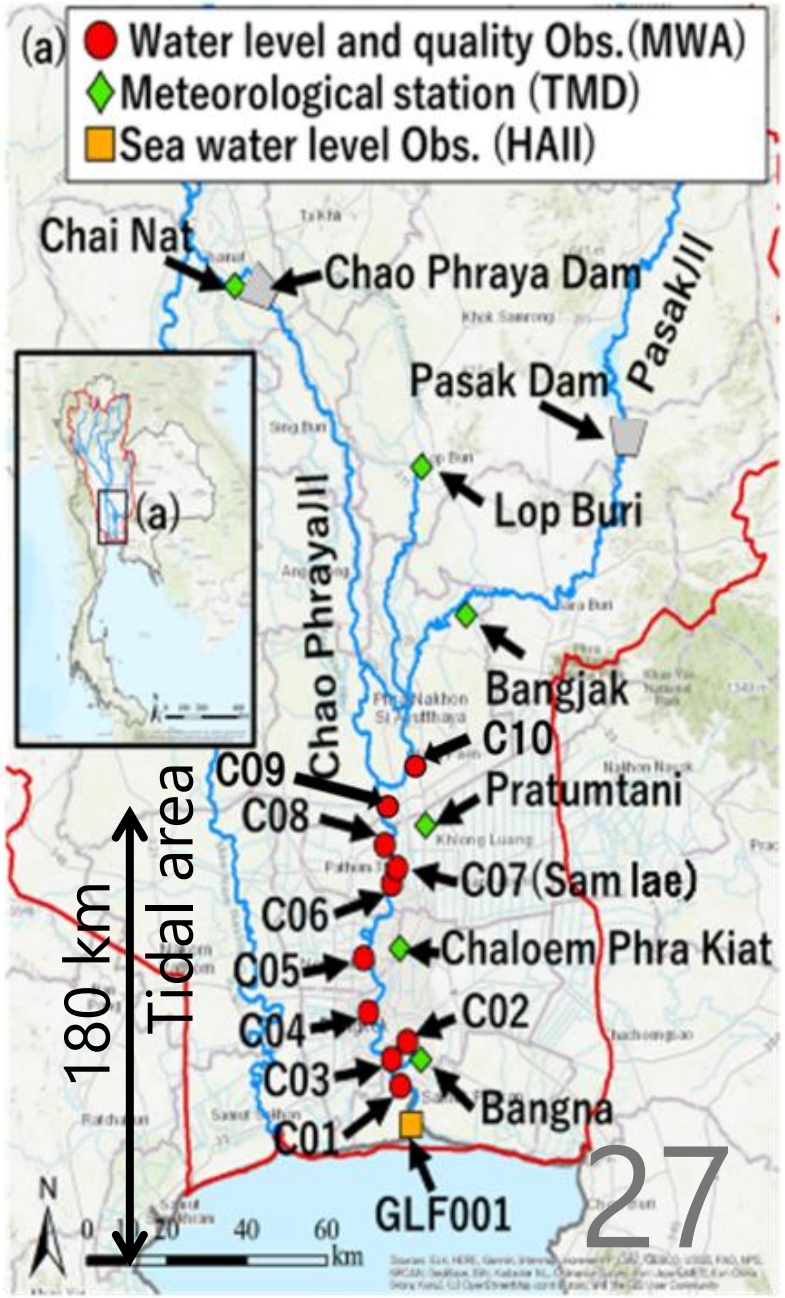



Salinity more than water quality standard in Samlae Pumping Station

| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|
| days | 14 | 14 | 0 | 18 | 79 | 62 | 0 | 0 | 16 |

Number of days that water withdrawal thresholds (0.5 psu) were exceeded

➡Number of days of water withdrawal restrictions



# Spatial distribution of saltwater intrusion

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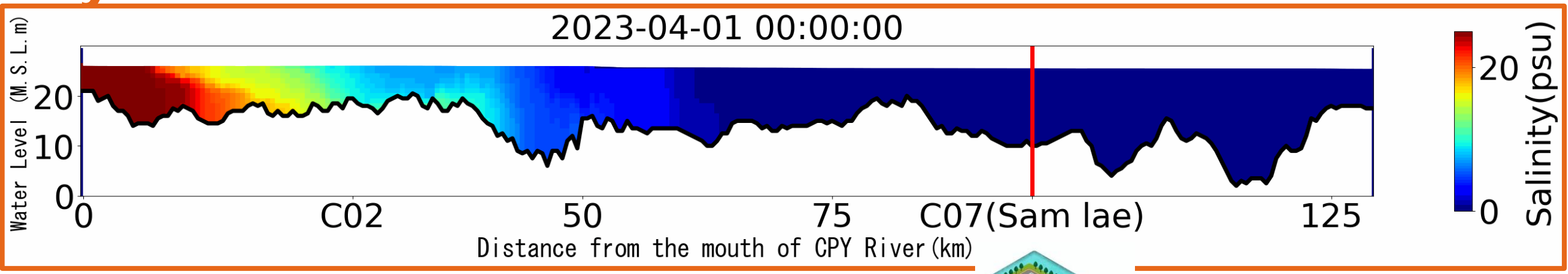
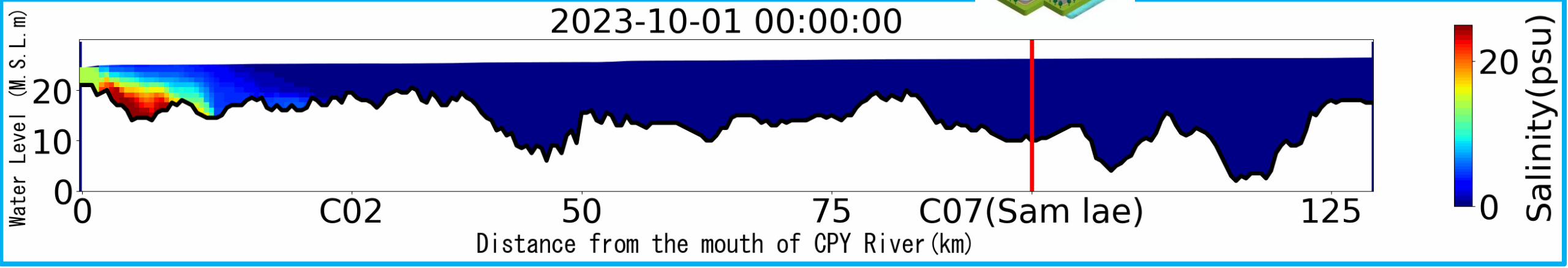
## Dry season

**Numerical simulation**




## Wet season

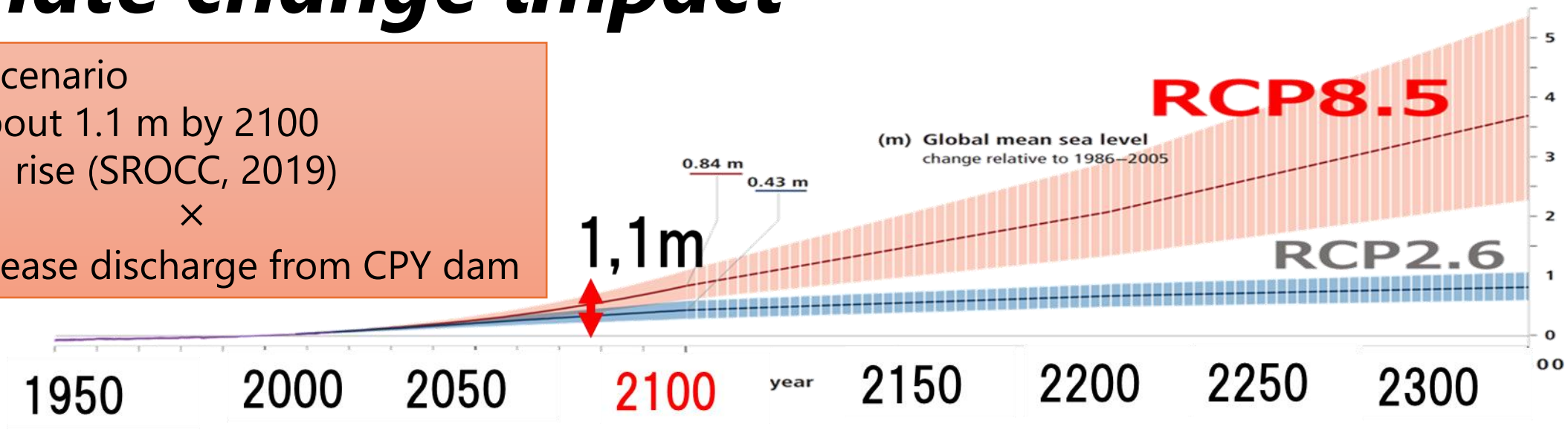


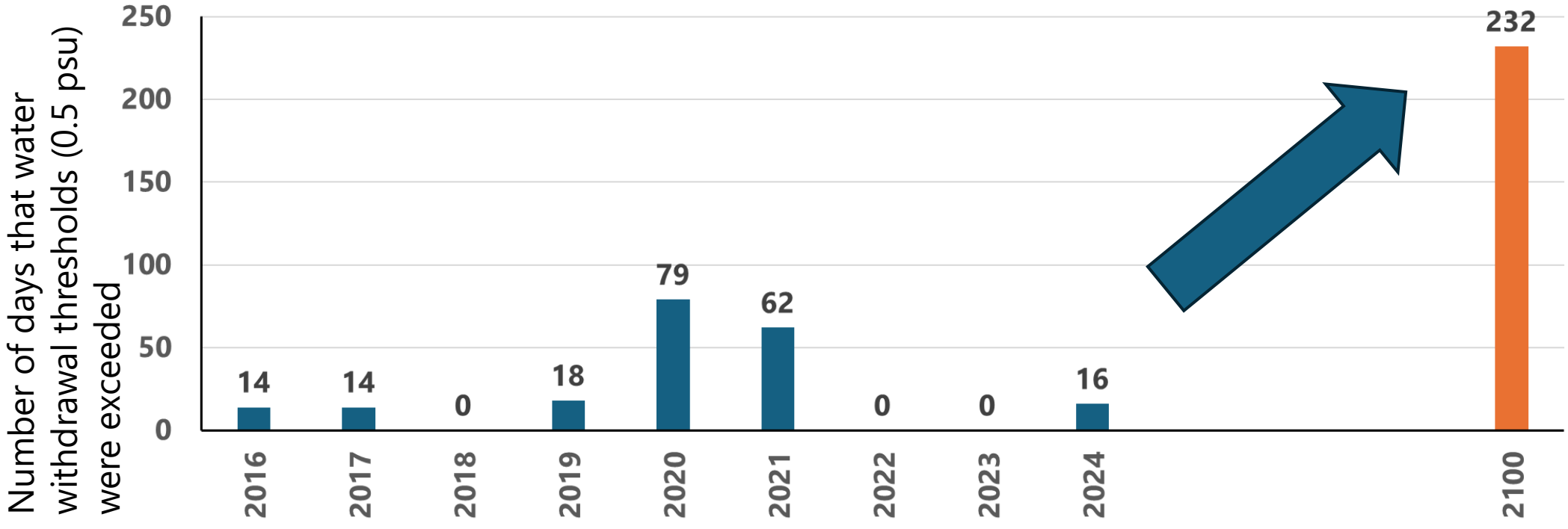

**Dry:** Strong mixing (characteristic of approximately uniform vertical distribution)

**WET:** Weak mixing (a property in which salts do not mix vertically and crawl up the riverbed)

# Climate change impact

RCP8.5 scenario
Up to about 1.1 m by 2100
Sea level rise (SROCC, 2019)
×
2023 Release discharge from CPY dam




Mr. Masuyama

# Urban Flood in Bangkok

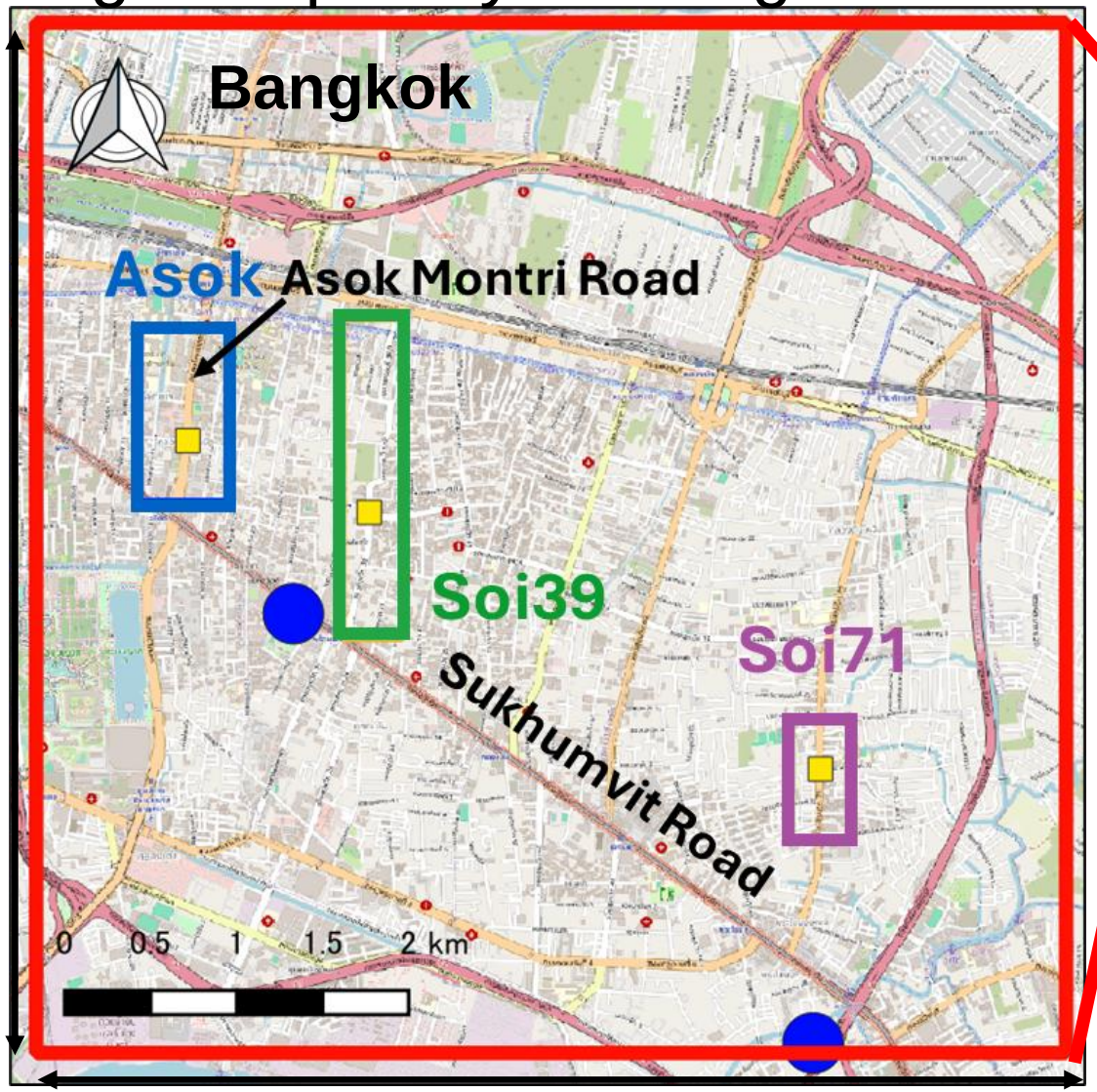




# High-resolution urban flooding model




High-frequency flooding areas



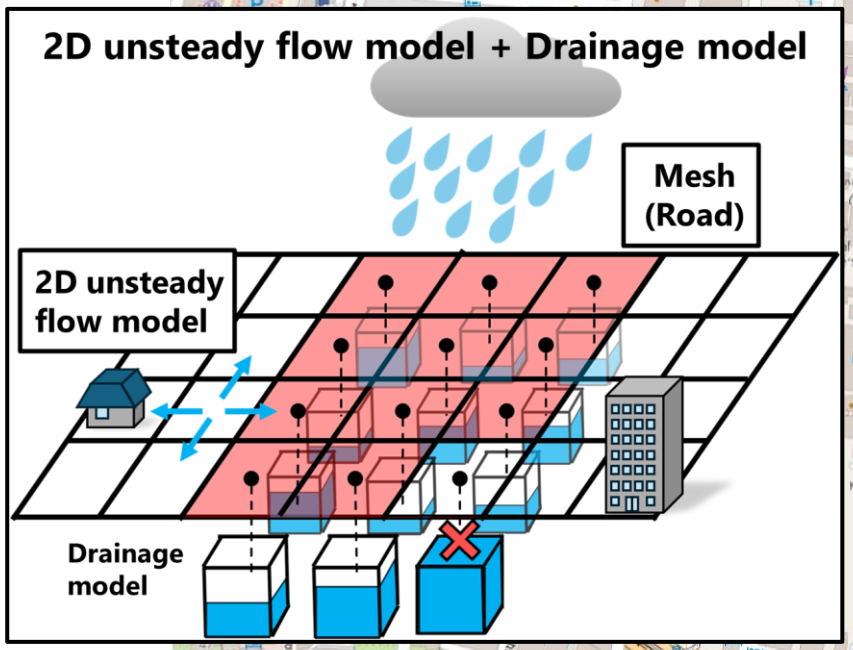


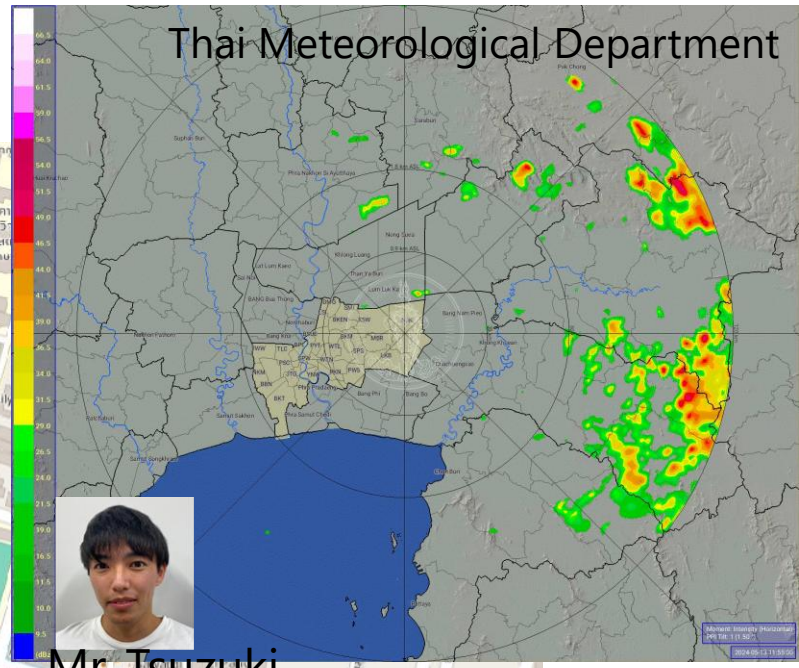
- Lack of hydraulic data for the model
- Complex drainage channels

# High-resolution urban flooding model

中央大学 CHUO UNIVERSITY Knowledge into Action

27, April, 2021, 13:00～15:10, Asok

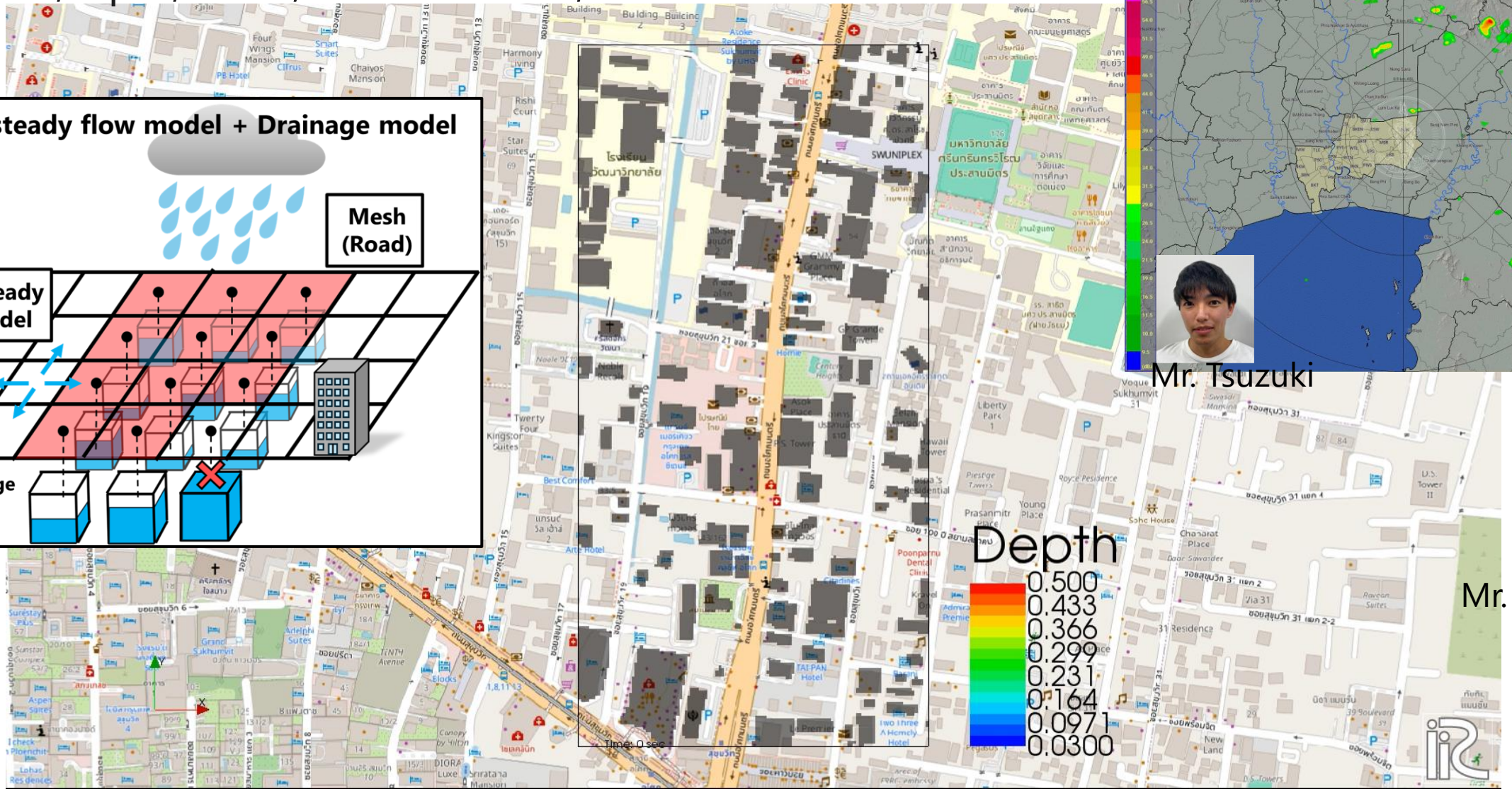





Mr. Tsuzuki

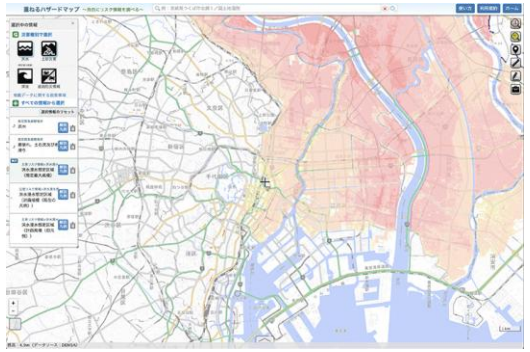
Mr. Kawamura



# Recommendations; intangible measures

1. *Urban flood hazard/risk map*
2. *Buildup of the observation system and its effective use (tide level, rainfall, sewage level)*
3. *Improving the accuracy of flood forecasting (from initial development of simplified models to more upgrade models)*
4. *Early warning system (Linkage with observation system and flood forecasting)*
5. *Establishment of evacuation systems*
6. *Increase in rainwater infiltration facilities, including on private land*

**Data Archives!!**

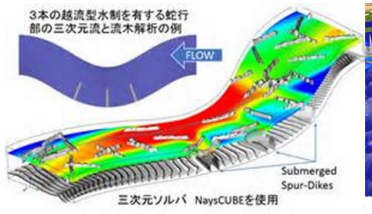


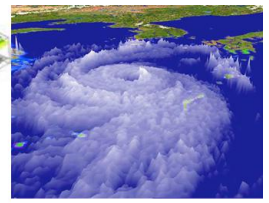
**More benefit**

- Traffic jam relief
- Avoidance of loss of tourism opportunities

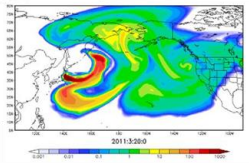

Rain garden in Yokohama


# Observation data is still extremely important



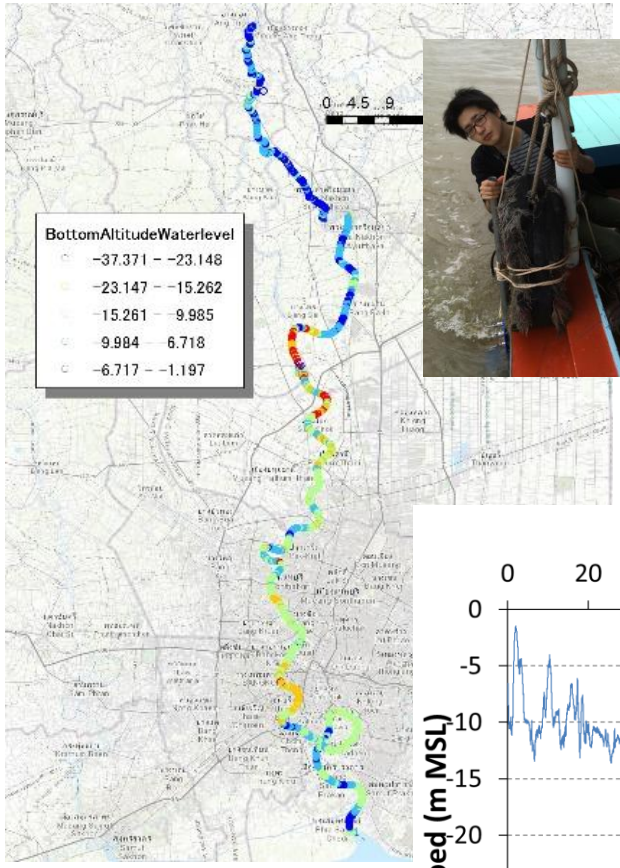



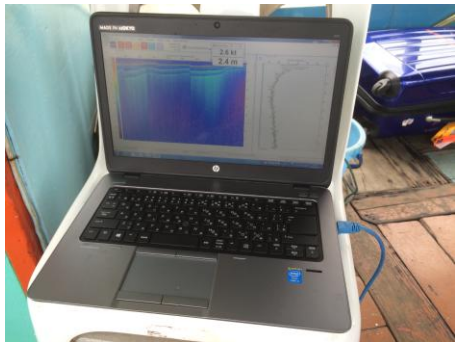
Simulations

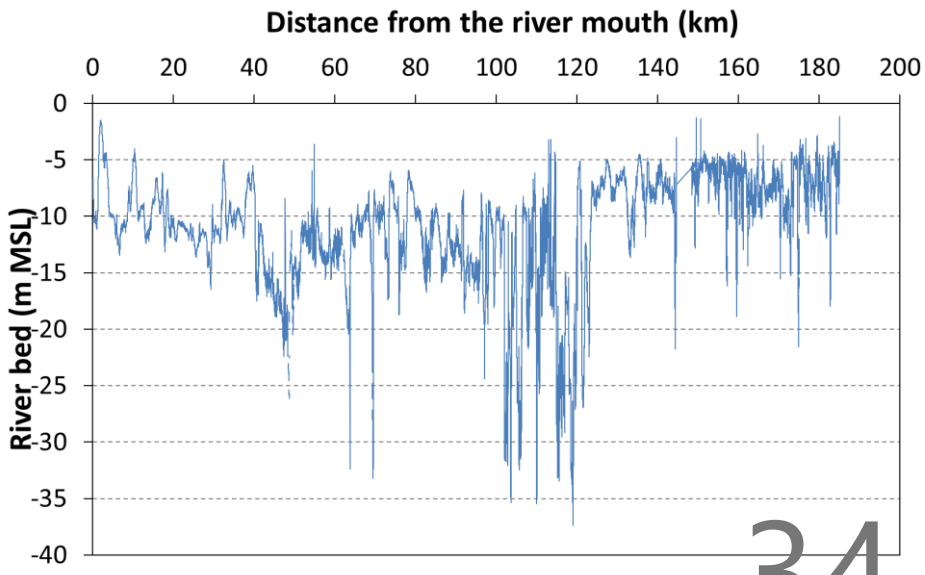


Observations

## Riverbed data from the river mouth to Angthong






# No Data, No Future!!