9th ASIAN REGIONAL CONFERENCE
Irrigation & Drainage
75TH IEC MEETING
1 - 7 Sept 2024 | ICC Sydney

國立中山大學 National Sun Yat-sen University
海洋環境及工程學系 Department of Marine Environment and Engineering

2024/9/2nd (Mon)
9th ASIAN REGIONAL CONFERENCE
Irrigation & Drainage
75th IEC Meeting

Development of an integrated framework for evaluating the effect of typhoon-induced inundation hazard on various agricultural crops

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Outline

- Introduction
- Methodology
- Application
- Results and Discussion
- Conclusion

Catastrophic Disasters

至少160人死亡，不過仍有數百人下落不明
原文網址: https://www.ettoday.net/news/20210717/2033320.htm#ixzz76MQG9D2j

2021/07 德國西部城市科隆（Cologne），13與14日降雨量就超過150毫米，幾乎是7月份平均降雨量的兩倍之多。
https://www.cna.com.tw/news/firstnews/202107170195.aspx

2021年7月河南水災，鄭州最大小時雨量達到了201.9公釐
https://newtalk.tw/news/view/2021-07-21/607497; https://news.ltn.com.tw/news/politics/paper/1462675

以美國東岸各州為主(紐約、紐澤西)，遭大西洋颶風「艾達」（Ida）所帶來的風暴殘餘威力強襲。截至當地時間2021年9月2日晚間11點為止，美國東北地區已知至少45死，其中在23死的紐澤西，大多數人是在行車中被沖走；至少13死的紐約市，則是因為多起「地下室公寓淹水」多人滅頂至死。https://global.udn.com/global_vision/story/8662/5719277

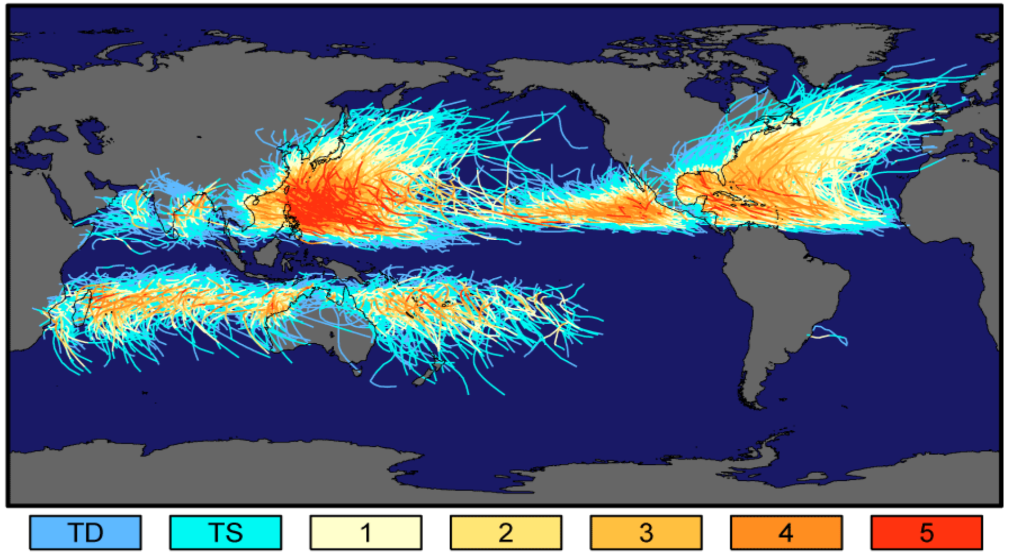
Tropical Cyclone

- Taiwan is located in one of the main paths of typhoons.

25.3

The climatological average number of typhoons formed annually in the Northwest Pacific over the period 1991-2020 is **25.3**, with the majority of typhoons forming between **July** and **October**.

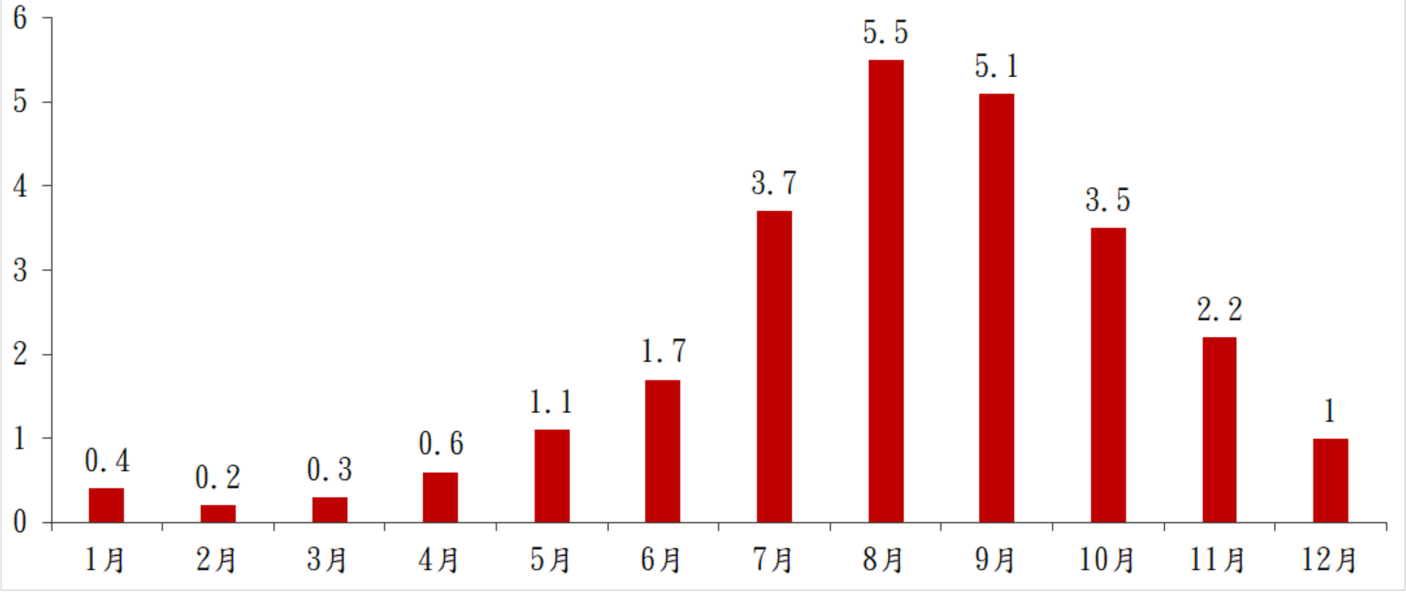
Tracks and Intensity of All Tropical Storms



Saffir-Simpson Hurricane Intensity Scale

Source: Ho, C. R., Tsao, Y. H., Kuo, N. J., & Huang, S. J. (2011, January). Estimation of Tropical Cyclone Heat Potential From Oceanic Mea surements. In International Conference on Offshore Mechanics and Arctic Engineering (Vol. 44380, pp. 817-822).

Number of Typhoons Formed in the Northwest Pacific (1991-2020)



Data Source: Central Weather Administration (CWA)

Disasters in Taiwan

- The torrential rainfall brought by typhoons frequently leads to serious disasters, such as inundation.

HAIKUI (2023)

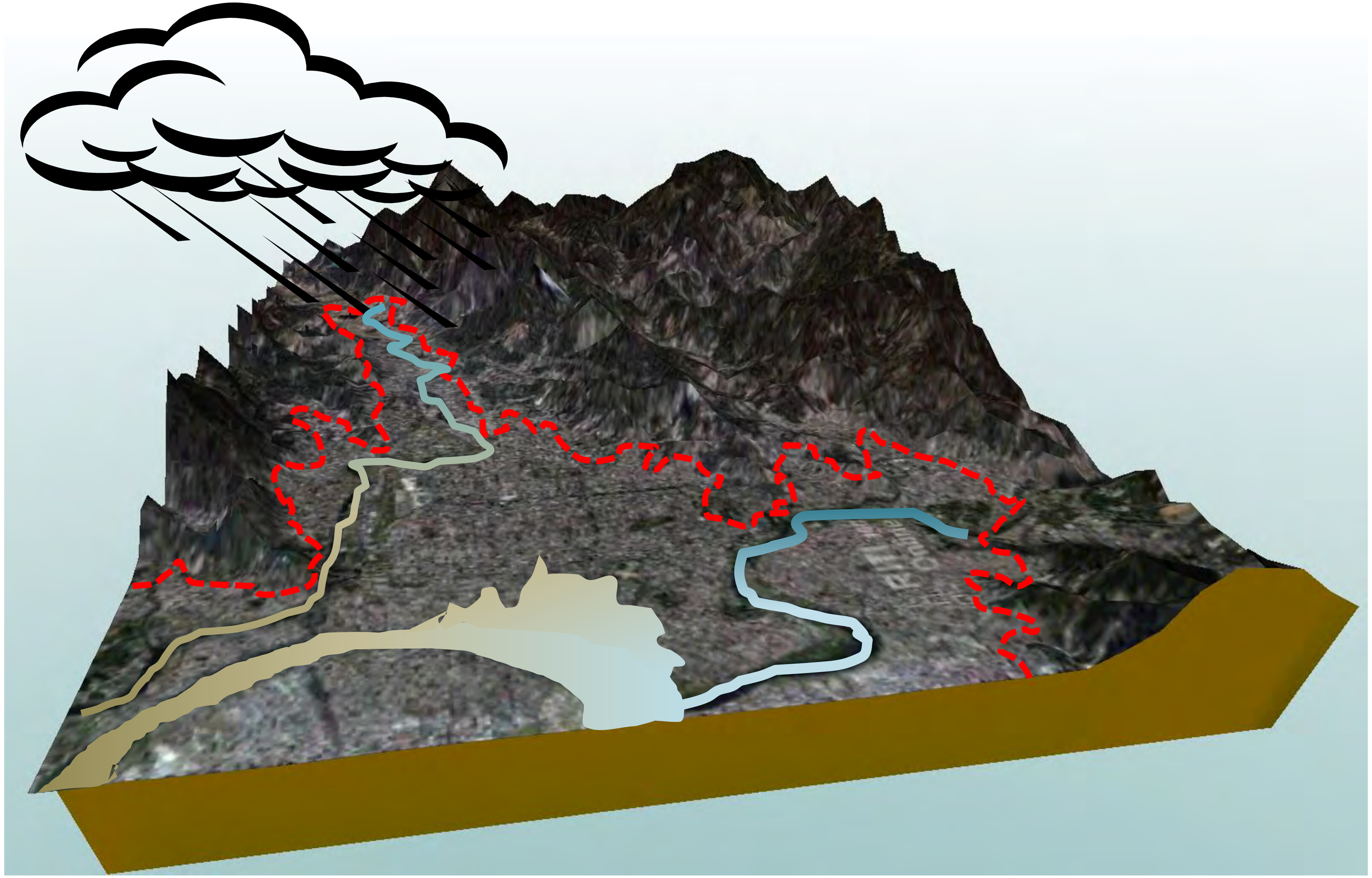
https://tw.news.yahoo.com/%E9%A2%B1%E9%A2%A8%E5%BE%8C%E8%8A%B1%E8%93%AE%E7%8E%89%E9%87%8C%E8%BE%B2%E7%94%B0%E6%B3%A1%E6%B0%B4-%E5%9C%96-055628196.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAADEZePHxF_P335FPfq62j6mod190gfm1xUSbPSgkH_8Gn_ql6ODGs02CSt84xeABvWj1fT2kaJjklwArAM3zuzbK6tu6baKS7pi-TwH8tp1jYIx_9VhB5XatFKTIm868jRVlO7ZJXs391wllQYHe96Ne9mdQlOVa7FAvc_0pXsWB

MERANTI (2016)

https://www.thenewslens.com/article/49528

https://www.agriharvest.tw/archives/25282

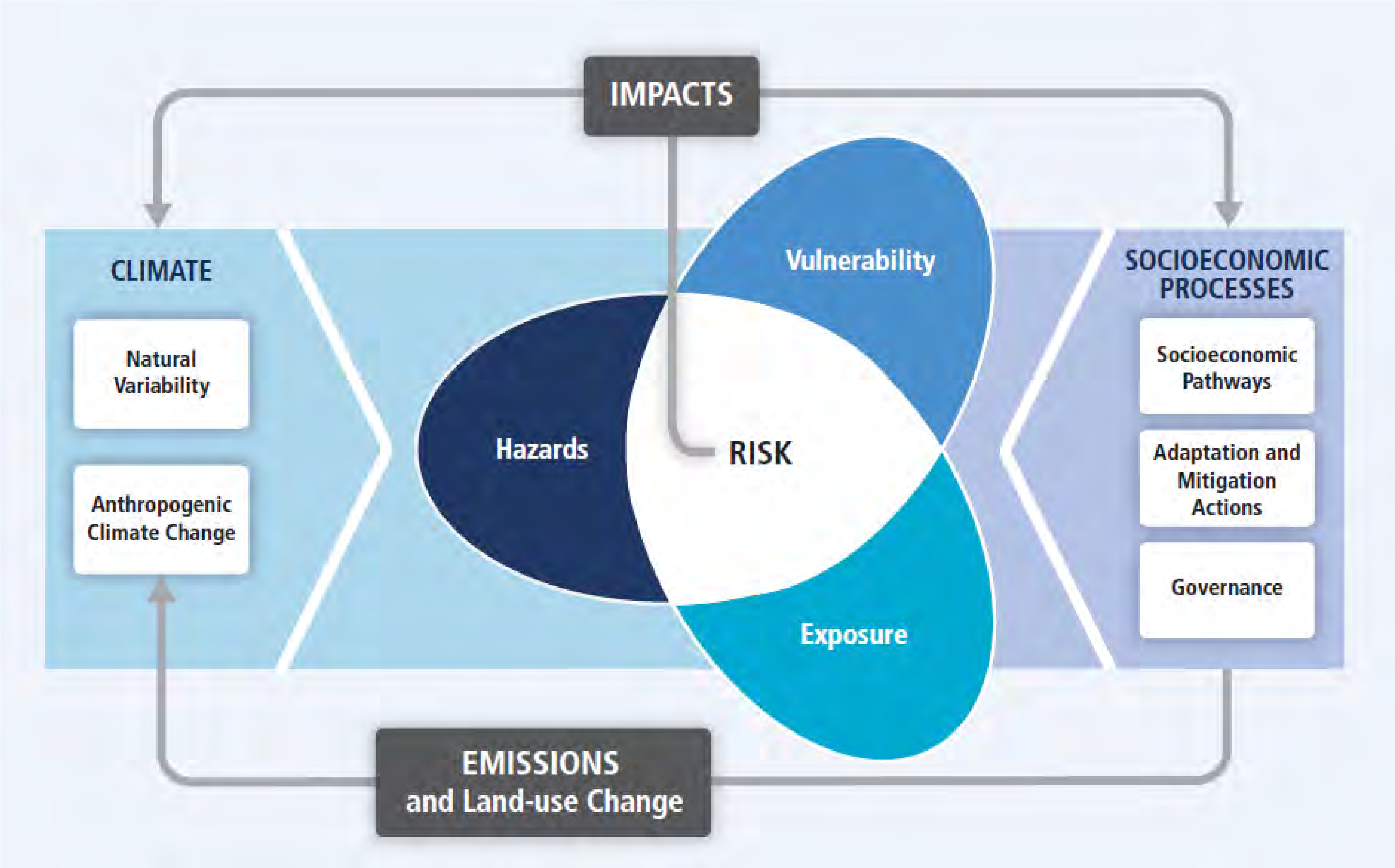
Warning system



- The **warning system** can increase the mitigation time,
- which is a consequence of a reduction in the time of several actions
  - such as data collection, emergency notification and decision making.

Climate Risk

	Warming Trend
	Extreme Temperature
	Drying Trend
	Extreme Precipitation
	Precipitation
	Snow Cover
	Damaging Cyclone
	Sea Level
	Carbon Dioxide Fertilization



Climate Change 2014 Synthesis Report (IPCC AR5)

Real-time Climate Risk Assessment

A comprehensive framework

Cause of risk resulted from climatic and non-climatic factors

Point A

Risk communication based on the same architecture

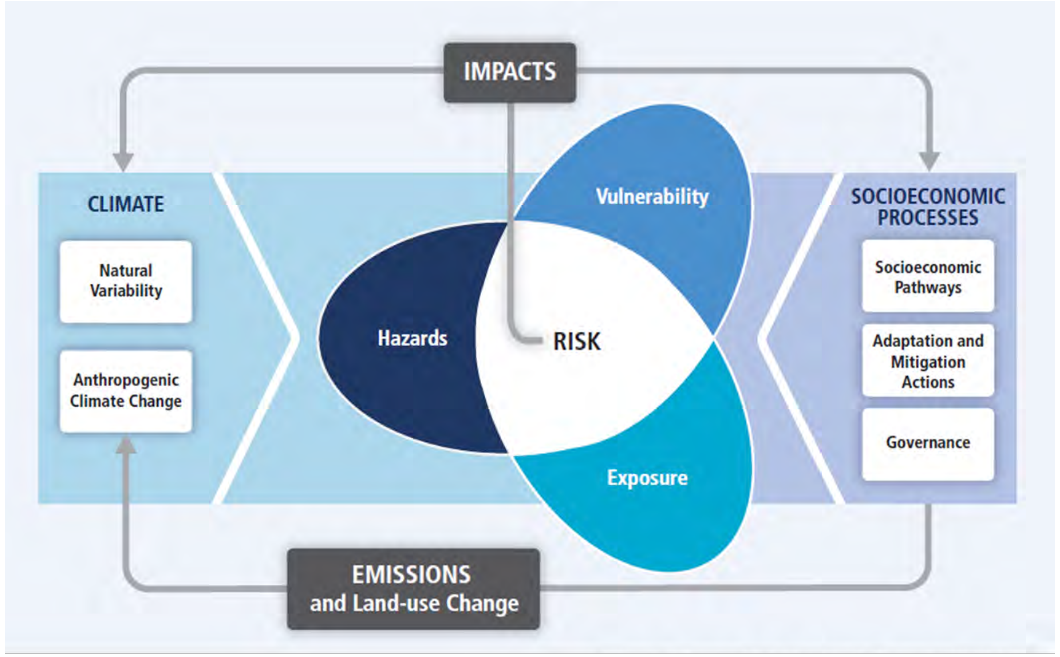
Point B

Interdisciplinary integration and assessment

Point C

Purpose

- Propose **<u>a generalized approach</u>** of assessing real-time inundation dynamic risks for paddy fields during typhoons
  - *Hazard*: Based on integrating a numerical model and AI-based approaches
  - *Exposure*: Protected target
  - *Vulnerability*: Sensitivity factors

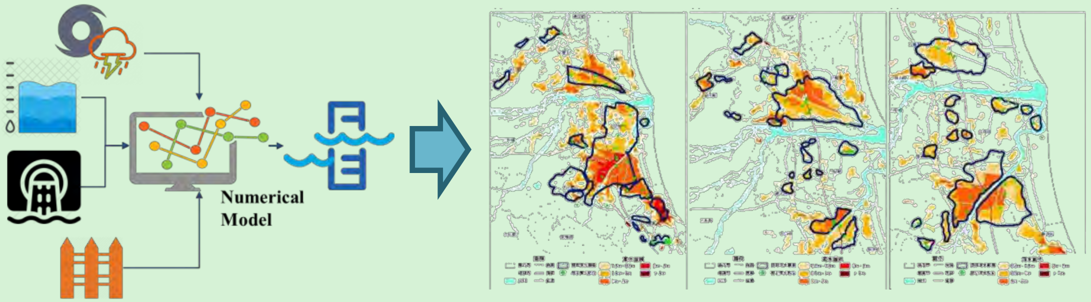


Climate Change 2014 Synthesis Report (IPCC AR5)

Proposed Integrated Framework

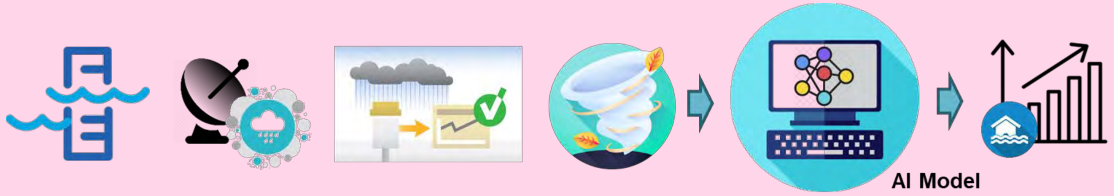
01 Numerical Model

- Inundation database simulation



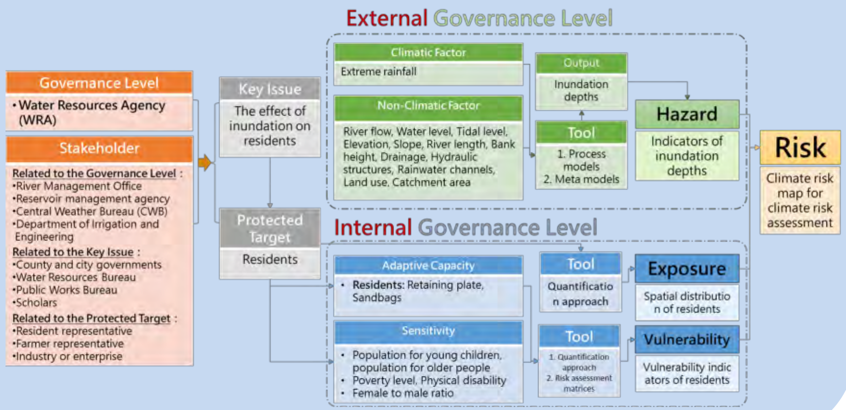
02 Forecasting AI Model

- Real-time forecasting of inundation depth
- An AI-based model with feature engineering



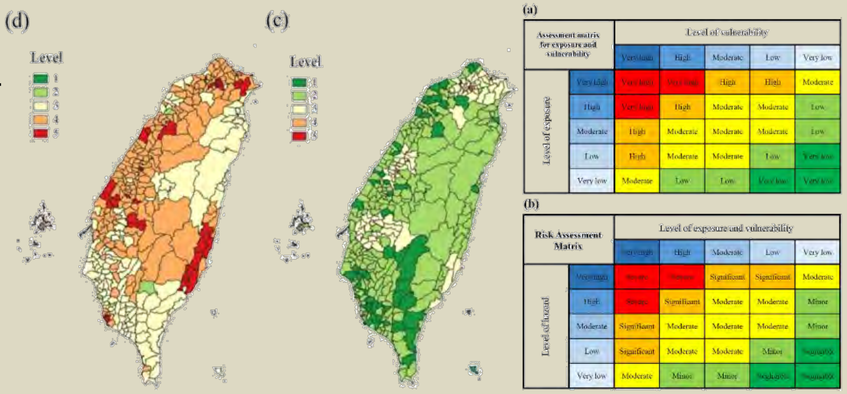
03 Climate Adaptation Algorithm

- Qualitative analysis
- Potential factors



04 Spatial Risk Assessment

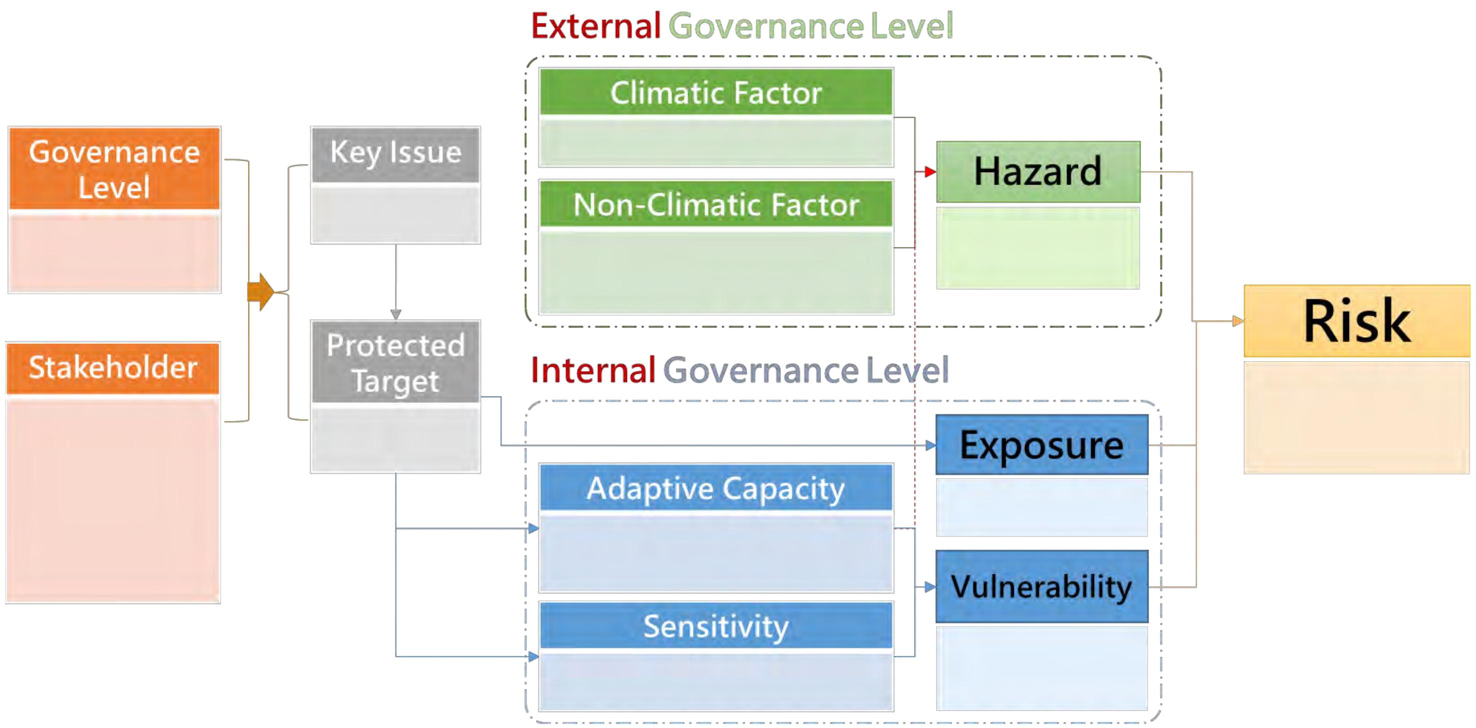
- Quantitative analysis
- Risk Maps



Climate Adaptation Algorithm

- Climate Change Adaptation 6-Steps (CCA6Steps)
- Climate Risk Template (CRT) (*Tung et al., 2019*)

Climate Change Adaptation 6-Steps

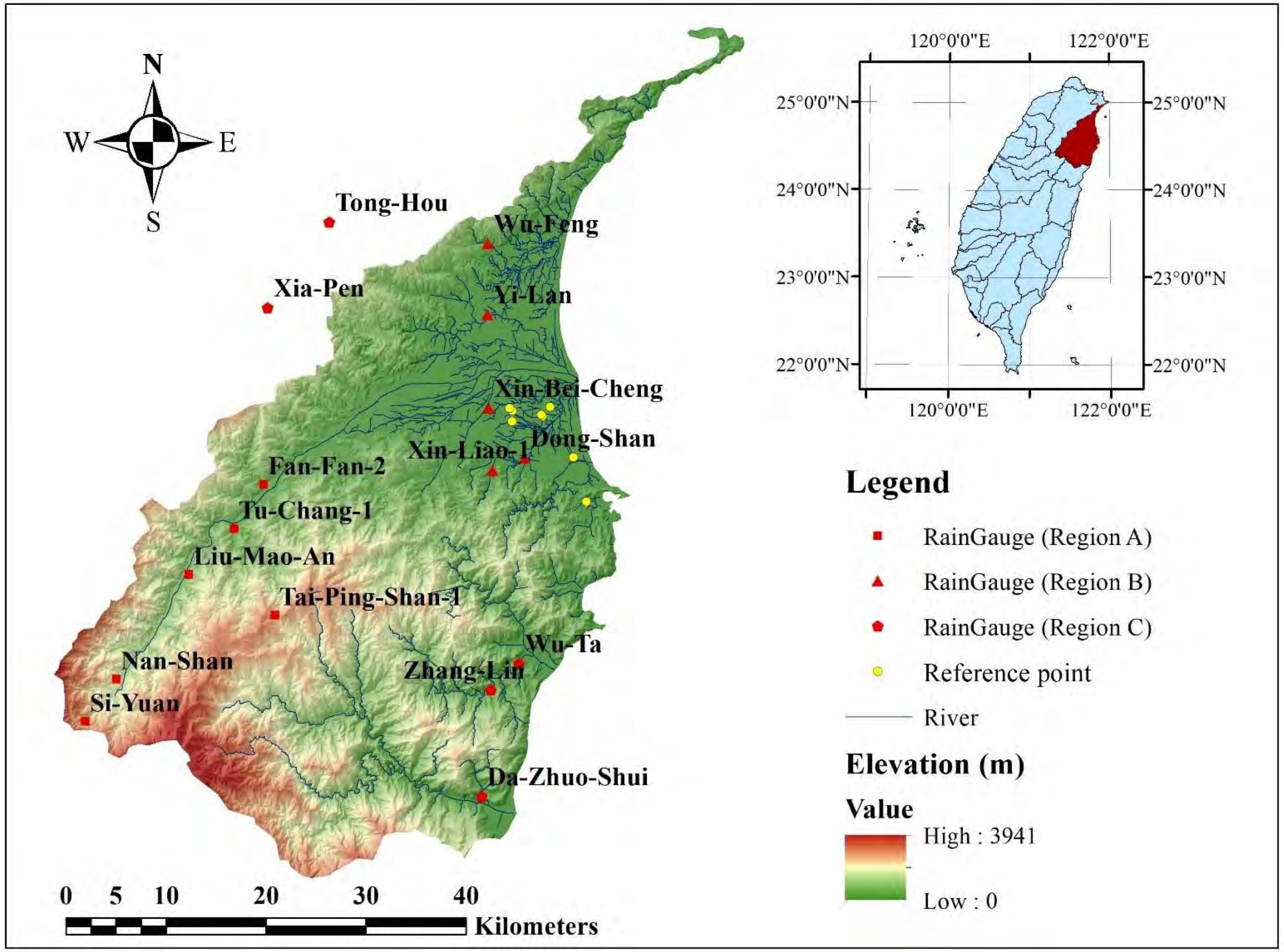


Climate Risk Template

Study Area

Yilan County

- The average annual rainfall is over 2,700 mm.
- Rainy days throughout one year is more than 200 days.
- 16 raingauges and 5 typhoon events (2008~2015) are used.
- 9 sites are selected as reference points.
- 6 points of sewer water level data were utilized.



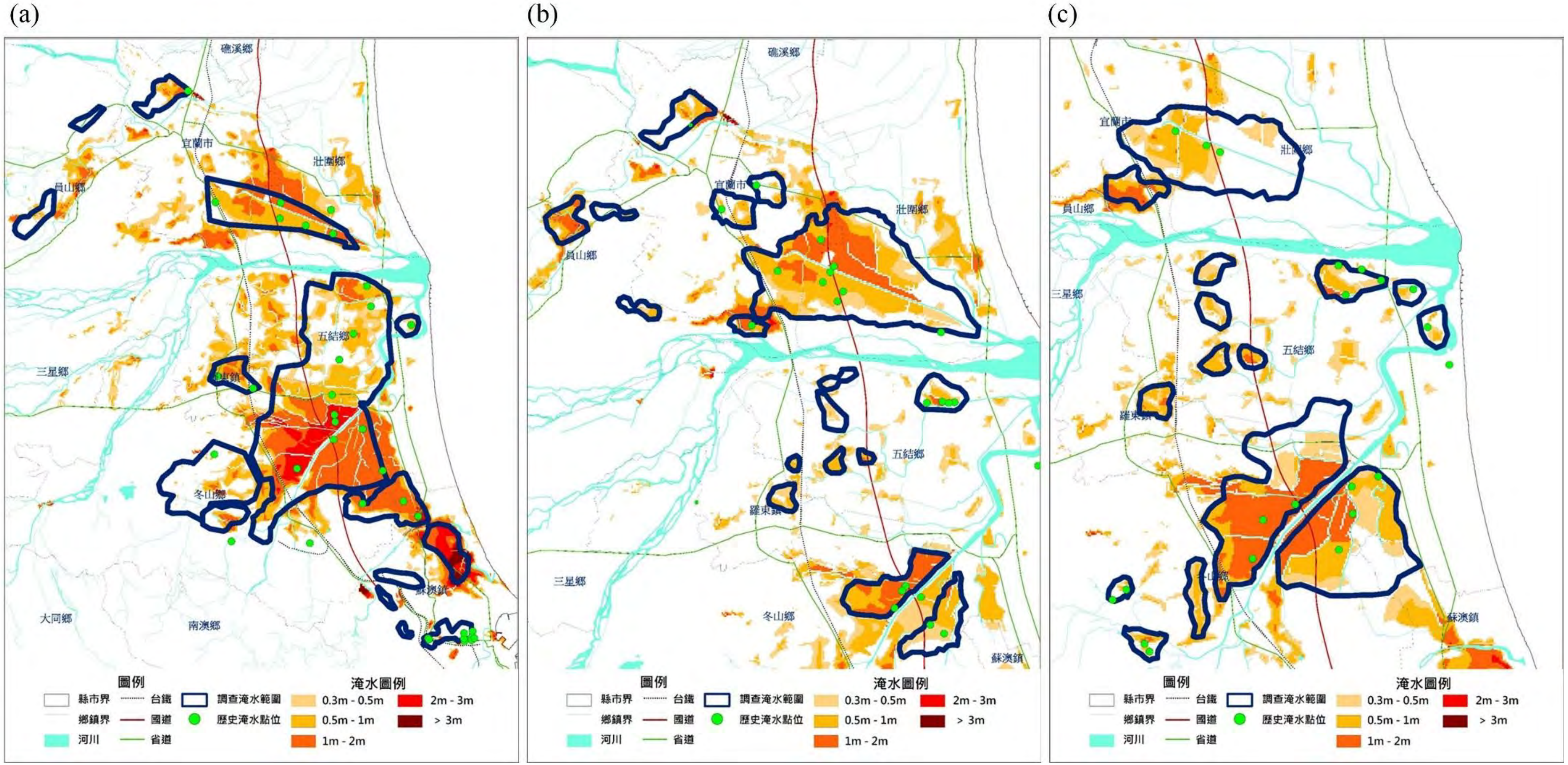
Hazard *(Inundation Database)*

- The flow overflow process and inundation components of the study area were simulated by SOBEK model.
- Calibration: (a) Typhoon Megi (2010) and (b) Typhoon Saola (2012); Validation: (c) Typhoon Parma (2009)

Hazard (H):

(Shrestha et al., 2014)

- I: 0~20 (cm)
- II: 20~50 (cm)
- III: 50~85 (cm)
- IV: 85~100 (cm)
- V: >100 (cm)



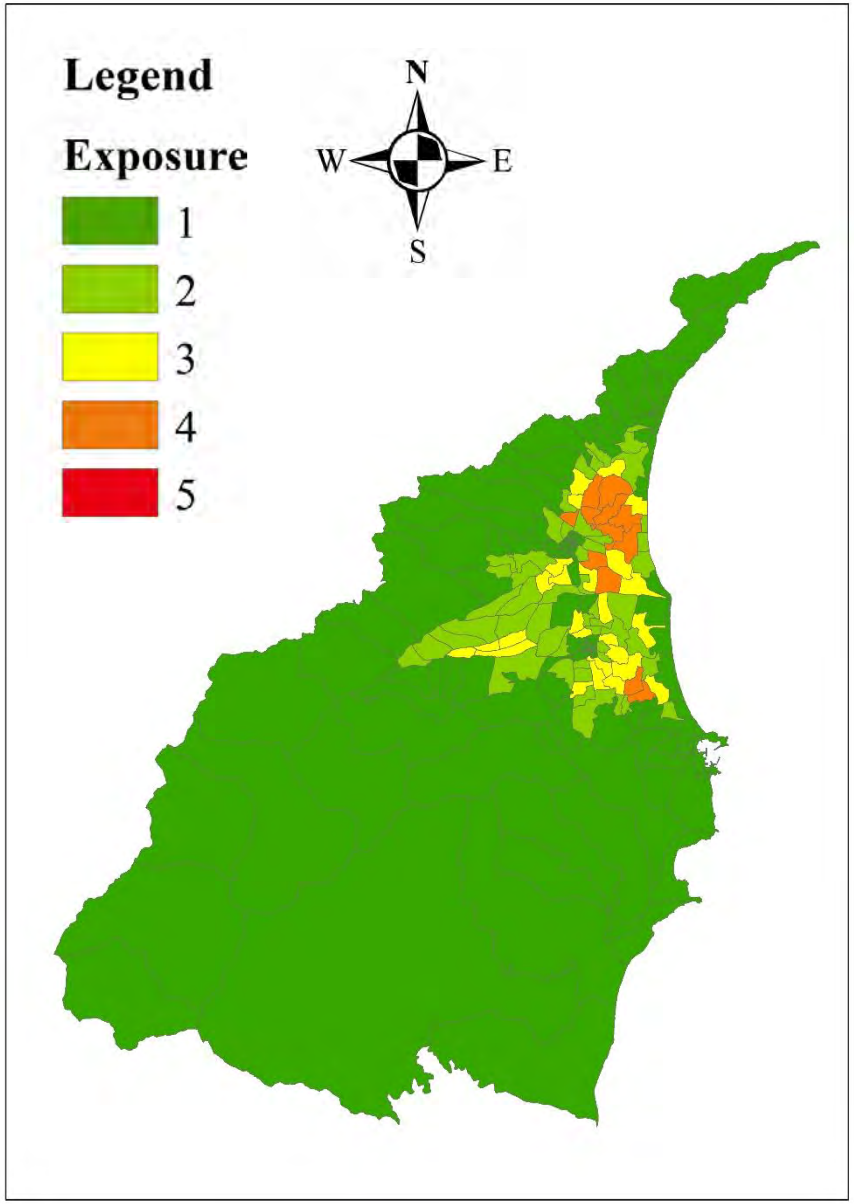
Exposure & Vulnerability

- Exposure (E):
  - The proportion of paddy field area to the total area within each administrative district.
- Vulnerability (V):

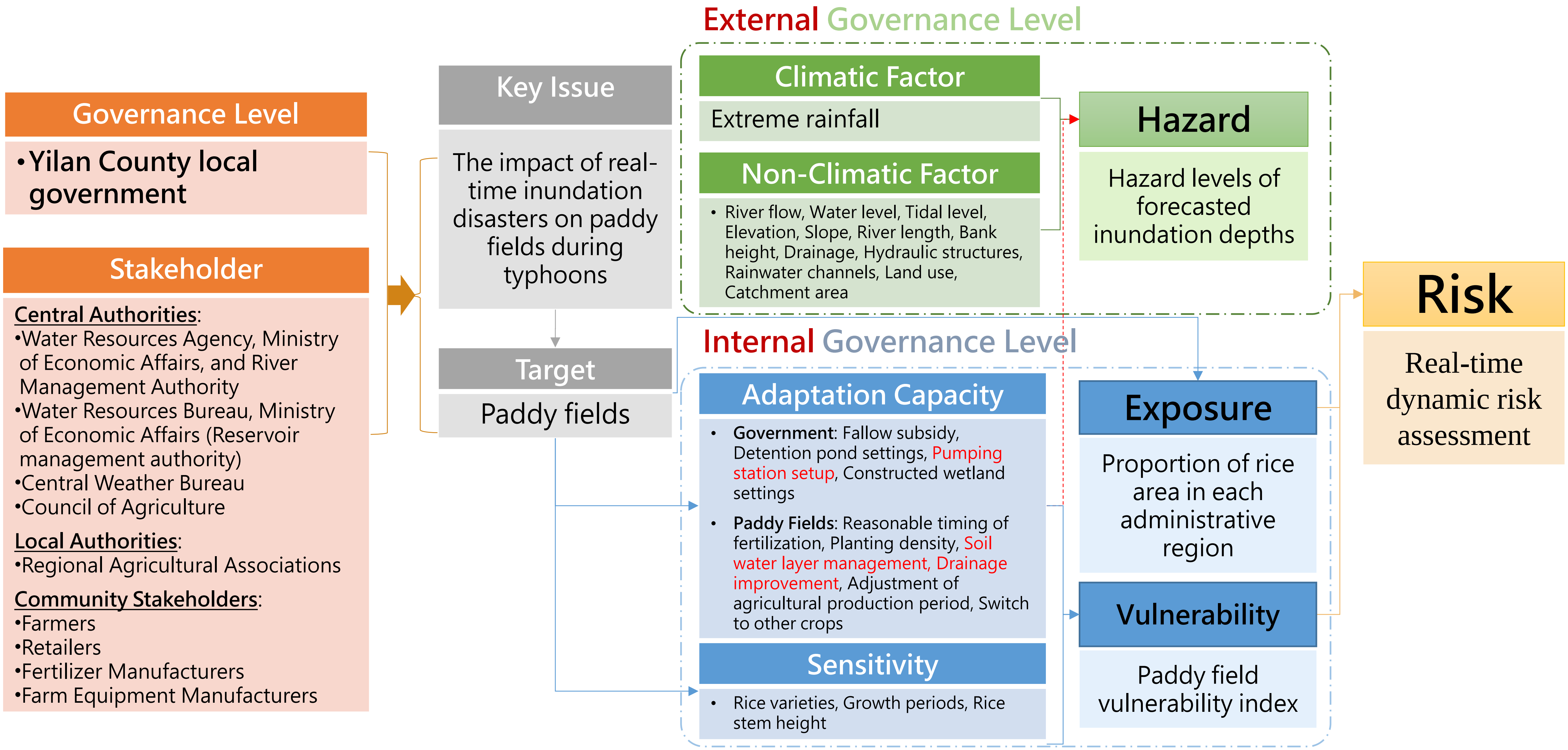
Levels:

- I: Maturity stage (成熟期)
- II: Heading stage (抽穗期)
- III: Booting stage (孕穗期)
- IV: Tillering stage (分蘖期)
- V: Seedling stage (秧苗期)

Target	Components	Factors	Indicators
Risk	Hazard	Climatic Factor	
		Non-Climatic Factor	
	Vulnerability	Adaptive Capacity (Government)	Fallow subsidy
			Detention pond settings
			Pumping station setup
			Constructed wetland settings
		Adaptive Capacity (Protected Target)	Reasonable timing of fertilization
			Planting density
			Soil water layer management
			Drainage improvement
			Adjustment of agricultural production period
			Switch to other crops
		Sensitivity	Rice varieties
			Growth periods
			Rice stem height
	Exposure	Exposure	Proportion of rice area in each administrative region



Results I: Qualitative investigation of potential factors by the CRT

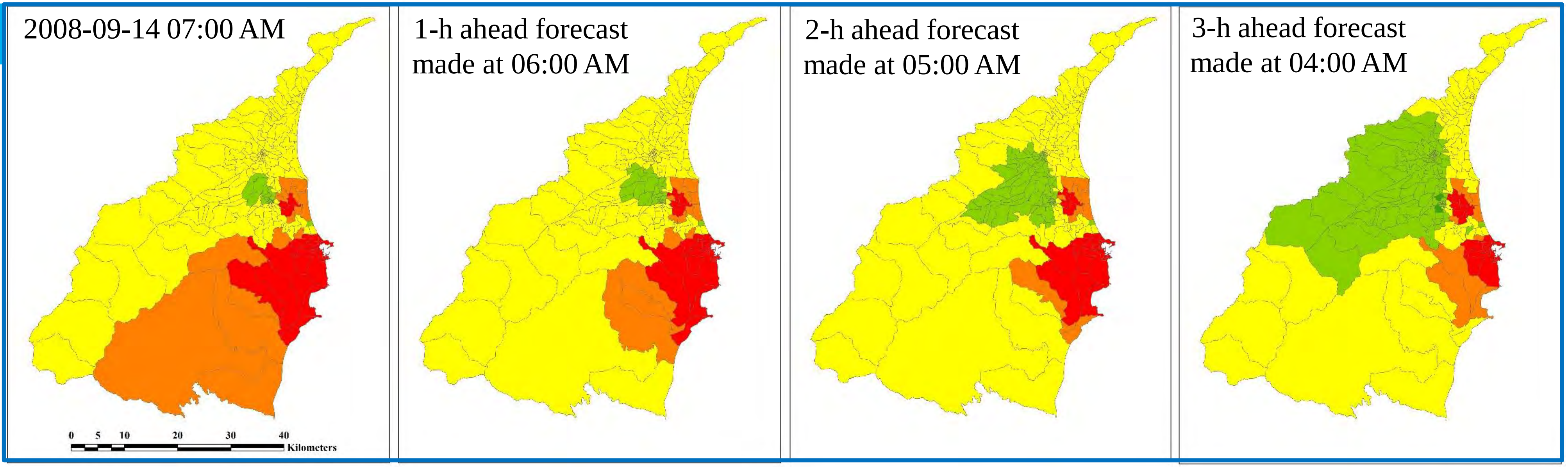


Results II: Spatial analysis of real-time inundation forecasts

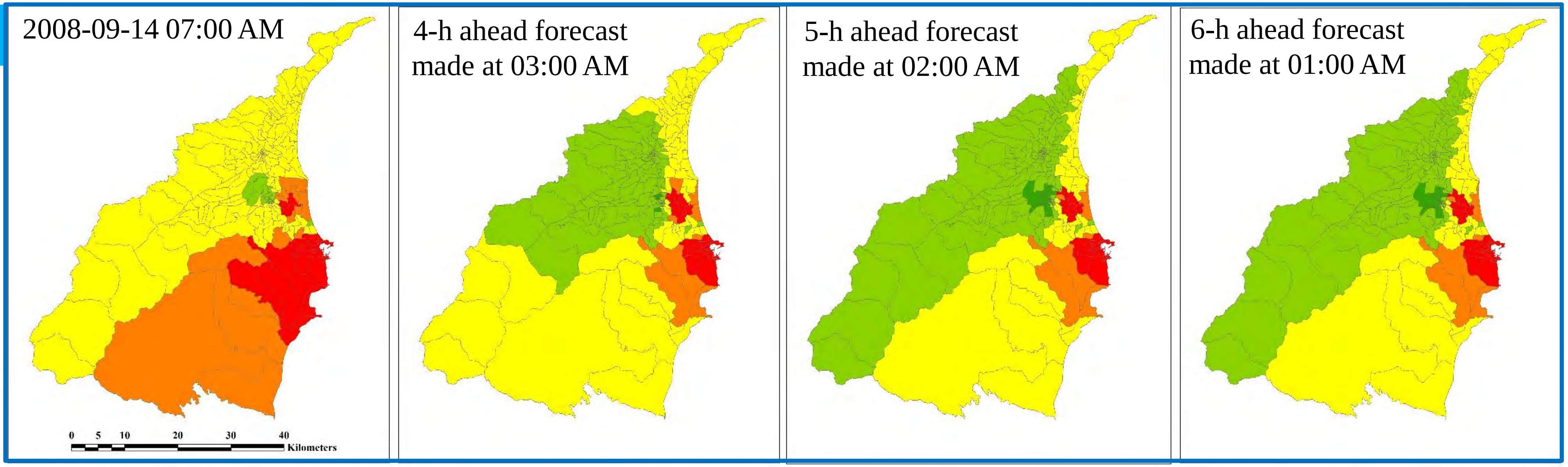
Typhoon SINLAKU (2008)

Short lead times

- Maximum value of inundation depth
- at 07:00 AM on Sep-10, 2008



Long lead times



Legend

Depth (cm)

- 0 - 20
- 21 - 50
- 51 - 85
- 86 - 100
- 101 - 142

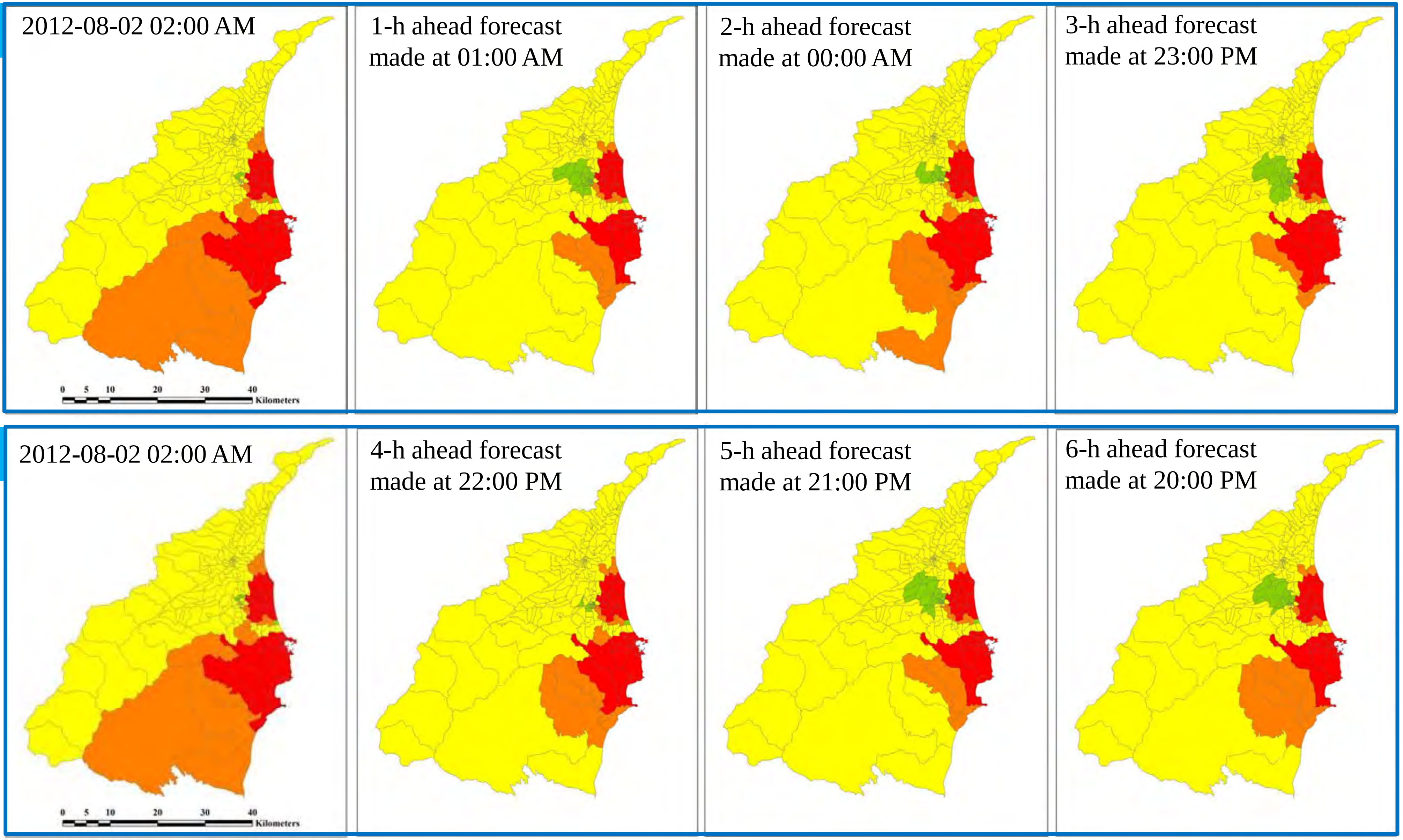
Results II: Spatial analysis of real-time inundation forecasts

Typhoon SAOLA (2012)

Short lead times

- Maximum value of inundation depth
- at 02:00 AM on Aug-2, 2012

Long lead times



Legend

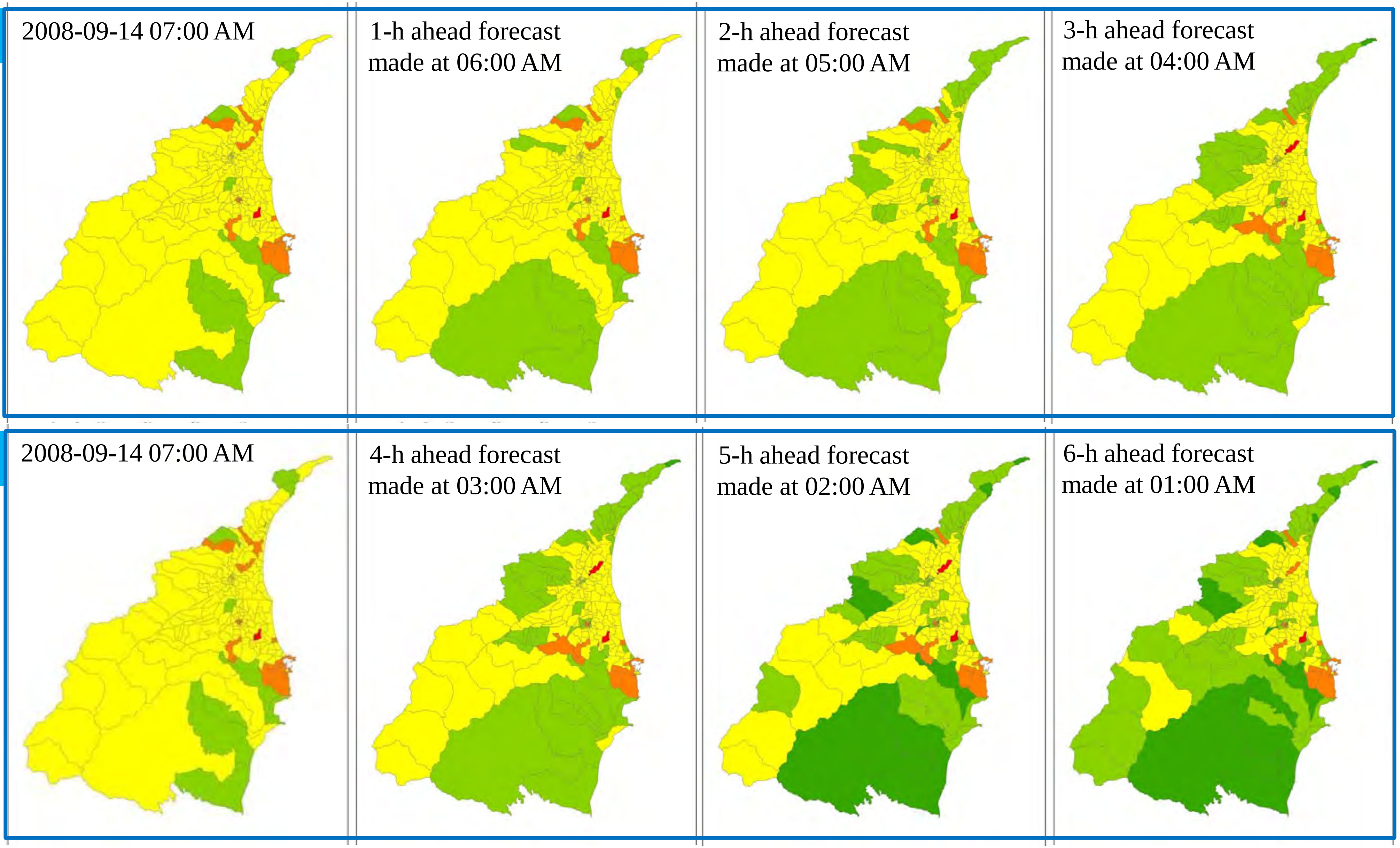
Depth (cm)

- 0 - 20
- 21 - 50
- 51 - 85
- 86 - 100
- 101 - 142

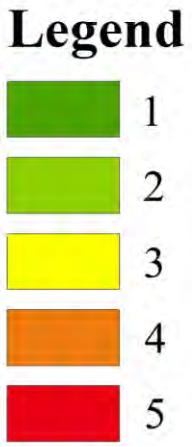
Results III: Real-time dynamic risk assessment results

Typhoon SINLAKU (2008)

Short lead times



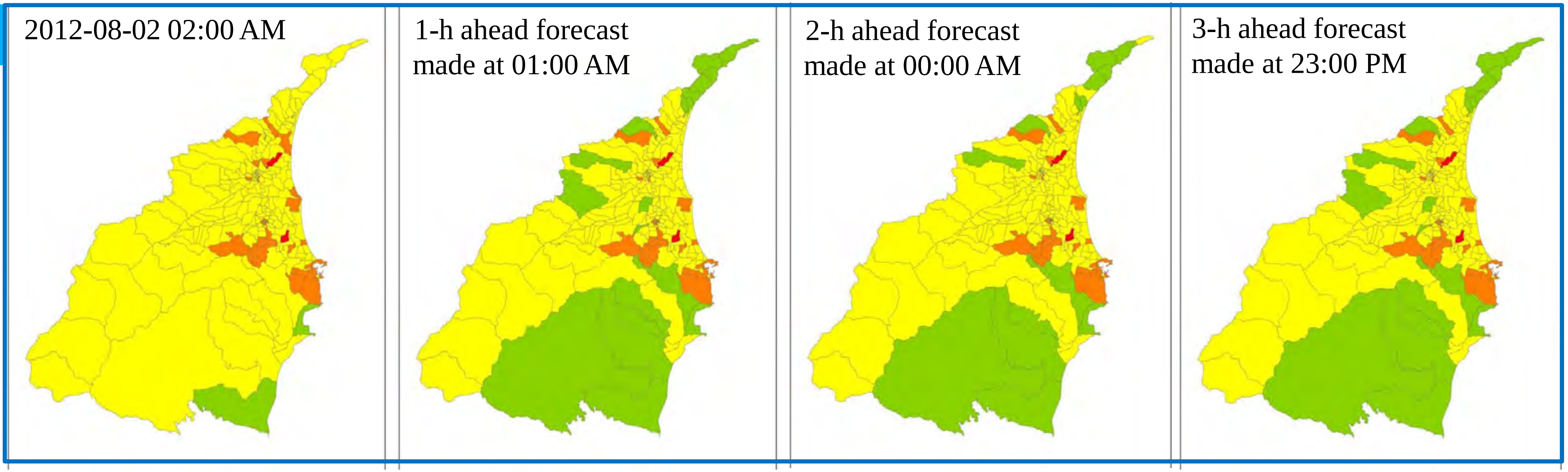
Long lead times



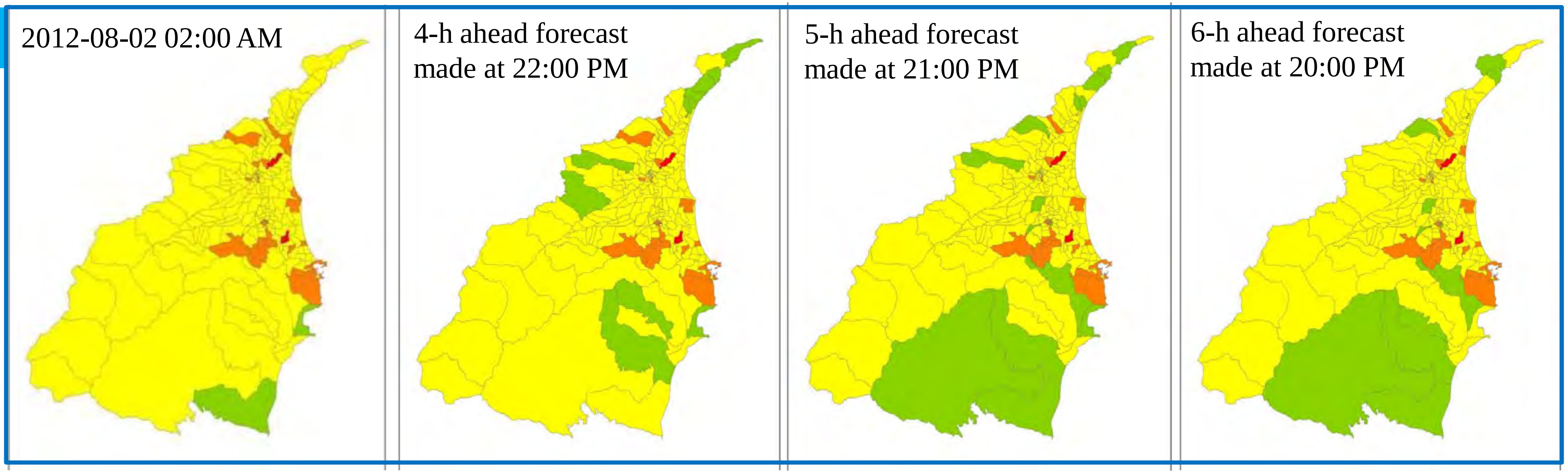
Results III: Real-time dynamic risk assessment results

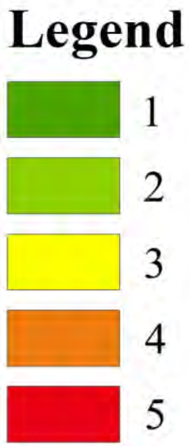
Typhoon SAOLA (2012)

Short lead times



Long lead times





Conclusion

- Based on real-time hourly inundation forecasts,
  - the dynamic risk affecting on paddy crops can be assessed.
- Using the CRT,
  - the potential factors of HEVR can be investigated for spatial risk assessment, and
  - the selection and implementation of adaptation measures can be further investigated.

The proposed approach is expected to be useful for agricultural disaster management.

Rerefence (Related)

1. Jhong BC*, Lin CY, Jhong YD, Chang HK, Chu JL, Fang HT, 2022.07, Assessing the effective spatial characteristics of input features by physics-informed machine learning in inundation forecasting during typhoons, *Hydrological Sciences Journal*, Vol. 67, No. 10, pp. 1527–1545. https://doi.org/10.1080/02626667.2022.2092406 (**SCI**)

2. Huang CC, Fang HT, Ho HC, Jhong BC*, 2019.06, Interdisciplinary application of numerical and machine-learning based models to predict half-hourly suspended sediment concentrations during typhoons, *Journal of Hydrology*, Vol. 573, pp. 661–675. https://doi.org/10.1016/j.jhydrol.2019.04.001 (**SCI**)

3. Jhong BC, Wang JH, Lin GF, 2017.04, An integrated two-stage support vector machine approach to forecast inundation maps during typhoons, *Journal of Hydrology*, Vol. 547, pp. 236–252. http://dx.doi.org/10.1016/j.jhydrol.2017.01.057 (**SCI**)

4. Jhong BC, Fang HT, Huang CC, 2021.05.11, Assessment of Effective Monitoring Sites in a Reservoir Watershed by Support Vector Machine Coupled with Multi-Objective Genetic Algorithm for Sediment Flux Prediction during Typhoons, *Water Resources Management*, Vol. 35, pp. 2387–2408. https://doi.org/10.1007/s11269-021-02832-4 (**SCI**)

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6. Tung CP, Tsao JH, Tien YC, Lin CY, Jhong BC*, 2019.03, Development of a novel climate adaptation algorithm for climate risk assessment, *Water*, Vol. 11, No. 3, 497. https://doi.org/10.3390/w11030497 (**SCI**)

7. Jhong BC*, Tung CP, 2018.07, Evaluating future joint probability of precipitation extremes with a copula-based assessing approach in climate change, *Water Resources Management*, Vol. 32, No. 13, pp. 4253–4274. http://dx.doi.org/10.1007/s11269-018-2045-y (**SCI**)

8. Jhong BC*, Huang J, Tung CP, 2019.06, Spatial assessment of climate risk for investigating climate adaptation strategies by evaluating spatial-temporal variability of extreme precipitation, *Water Resources Management*, Vol. 33, No. 10, pp. 3377–3400. https://doi.org/10.1007/s11269-019-02306-8 (**SCI**)

Thank you for your attention!

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Final Remarks



Future Sustainable and Quality Life