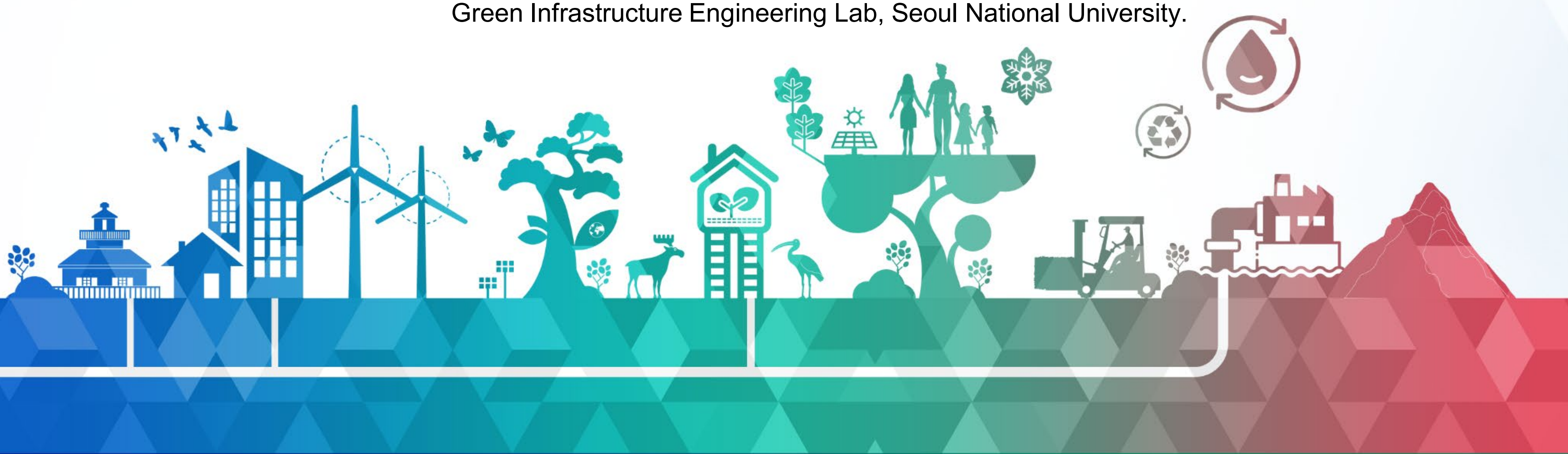
Evaluating Future Flood Risk Under Climate Change in a Monsoon Watershed.

25.06.26

Agbortoko Bate Ashu, Ph.D.; Junsuk Kang, Ph.D.; Youngho Kwon and Gunhee Lee

Green Infrastructure Engineering Lab, Seoul National University.



1 Introduction

Climate change is altering weather patterns, leading to more extreme and frequent floods and droughts worldwide.

South Korea is not exempt from experiencing these climate change effects, particularly in terms of shifting rainfall patterns and intensity.

Over the last decade, South Korea has experienced several flood events resulting in infrastructure and agriculture damage.

Fig 1. Images of flood events in South Korea.

1 Introduction

❖ **Background**: Global Climate Models

❖ Global climate models have been developed to project future climate change.

❖ The Shared Socioeconomic Pathways scenario encompasses demographics, economic development, welfare, ecosystem elements, resources, institutions, technological developments, social factors, and policies.

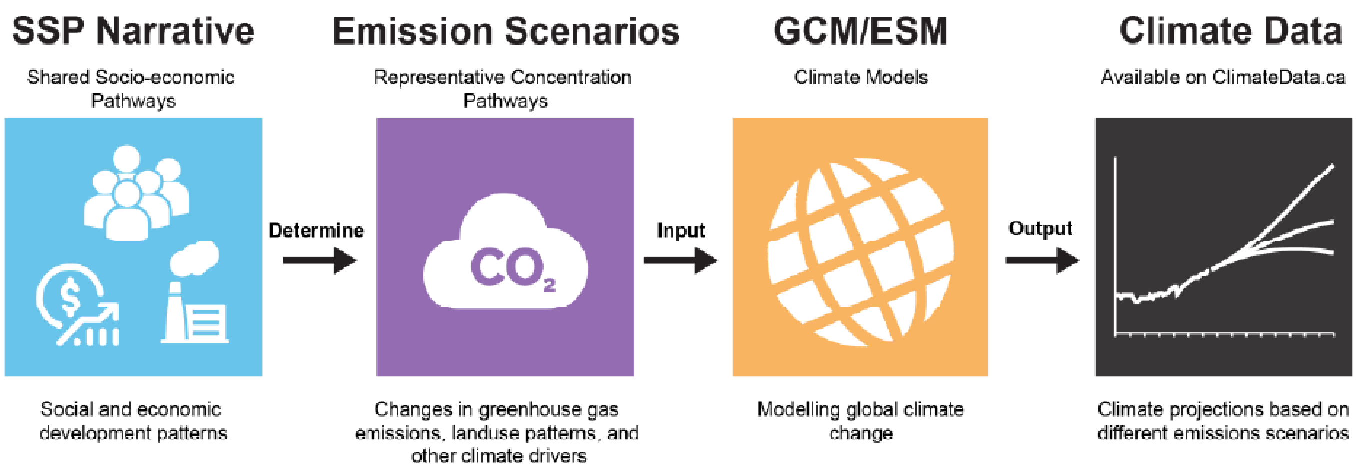


Fig 2. The sequence of information used to project future levels of climate change.

1 Introduction

❖ **Background:** Climate change impacts

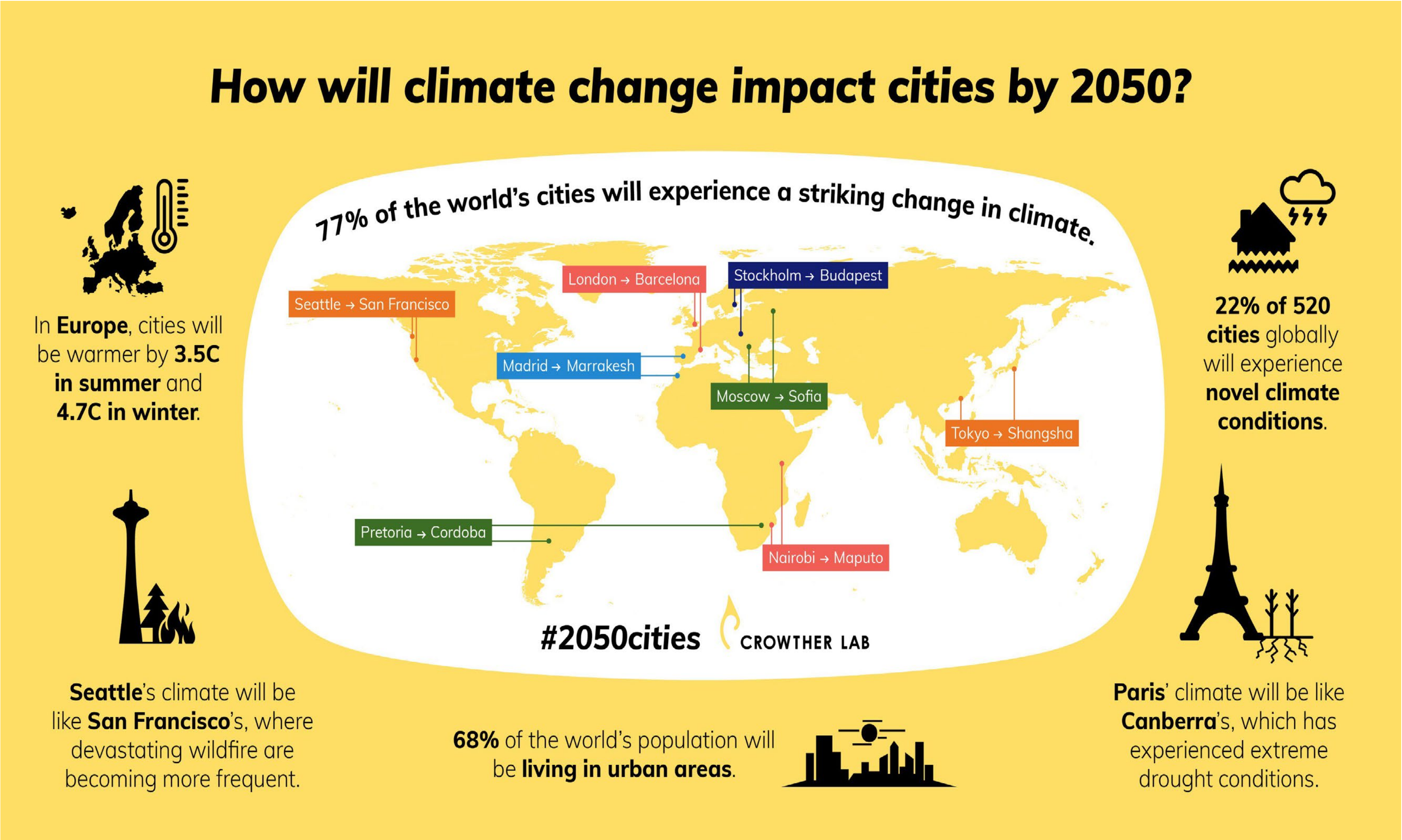


Fig. 3. Global data map visualization of climate change impacts on cities by 2050 concept from the Crowther Lab

1 Introduction

❖ **Background:** Flood risk assessment

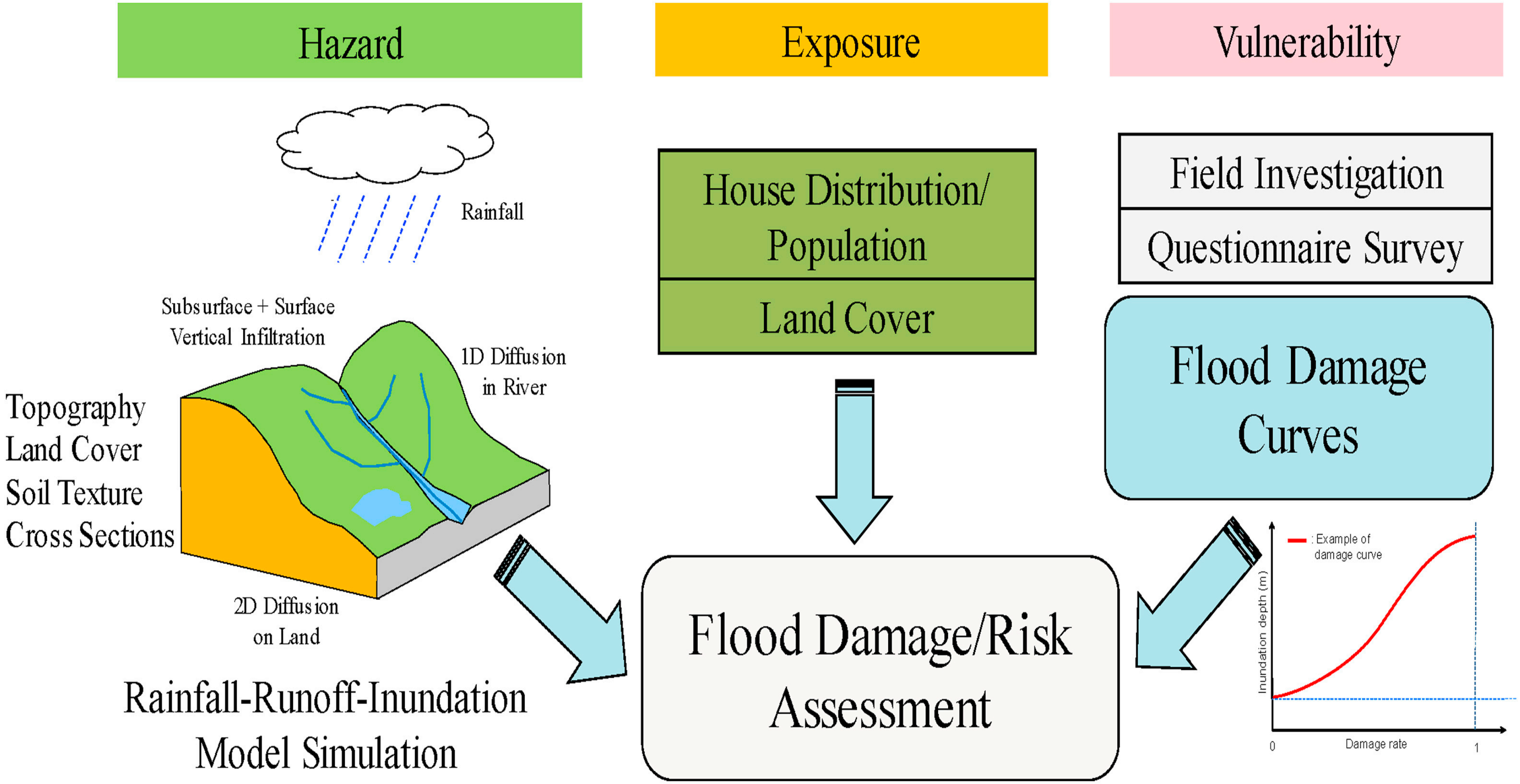


Fig. 4. Flood risk assessment literature review

2 Research Objectives

❖ This study aimed to assess the effects of future climate impacts on river floods in an agricultural watershed with multiple dams and reservoirs used for irrigation.

❖ We used a watershed model of the Yeongsan River watershed in South Korea, constructed using SWAT to estimate daily streamflow and assessed four indices to quantify different aspects of future flood risk of a two-year return flood period.

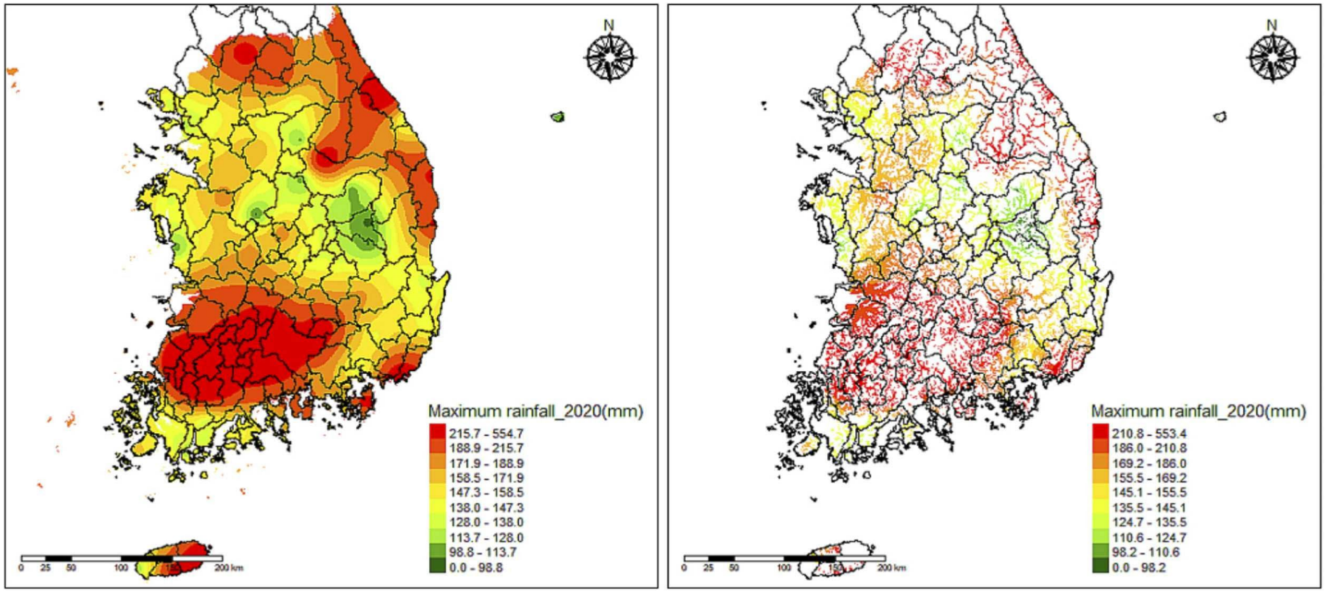


Fig 5. National grid-based maximum rainfall for 2020 (left) and maximum rainfall within the flood risk map (right).

3 Materials and methods

❖ Study Area

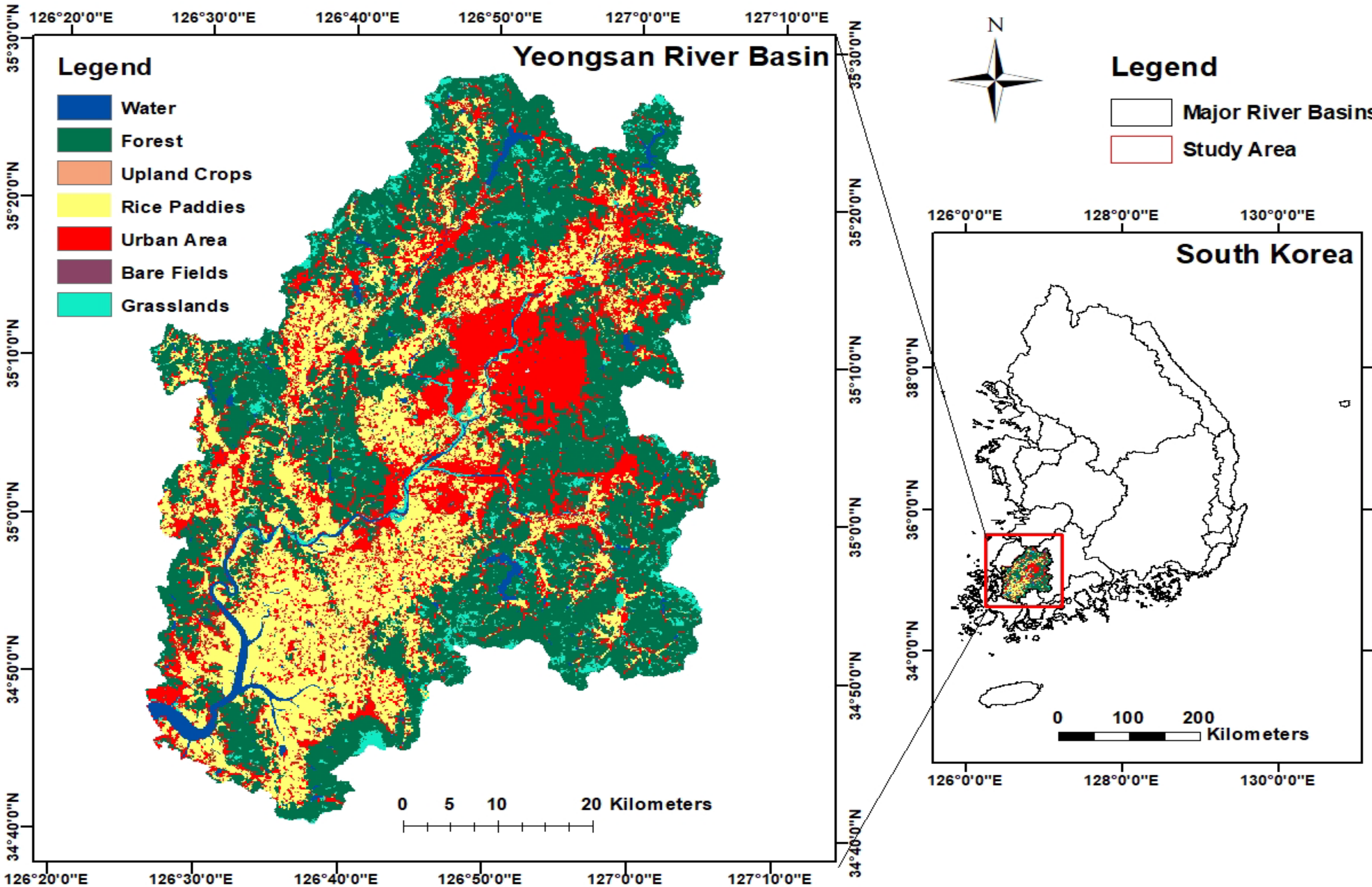


Fig. 6. Map of the study area including A) the location of the modelled area B) the drainage system model and C) land cover map.

3 Materials and methods

❖ **Methods:** Research Flowchart

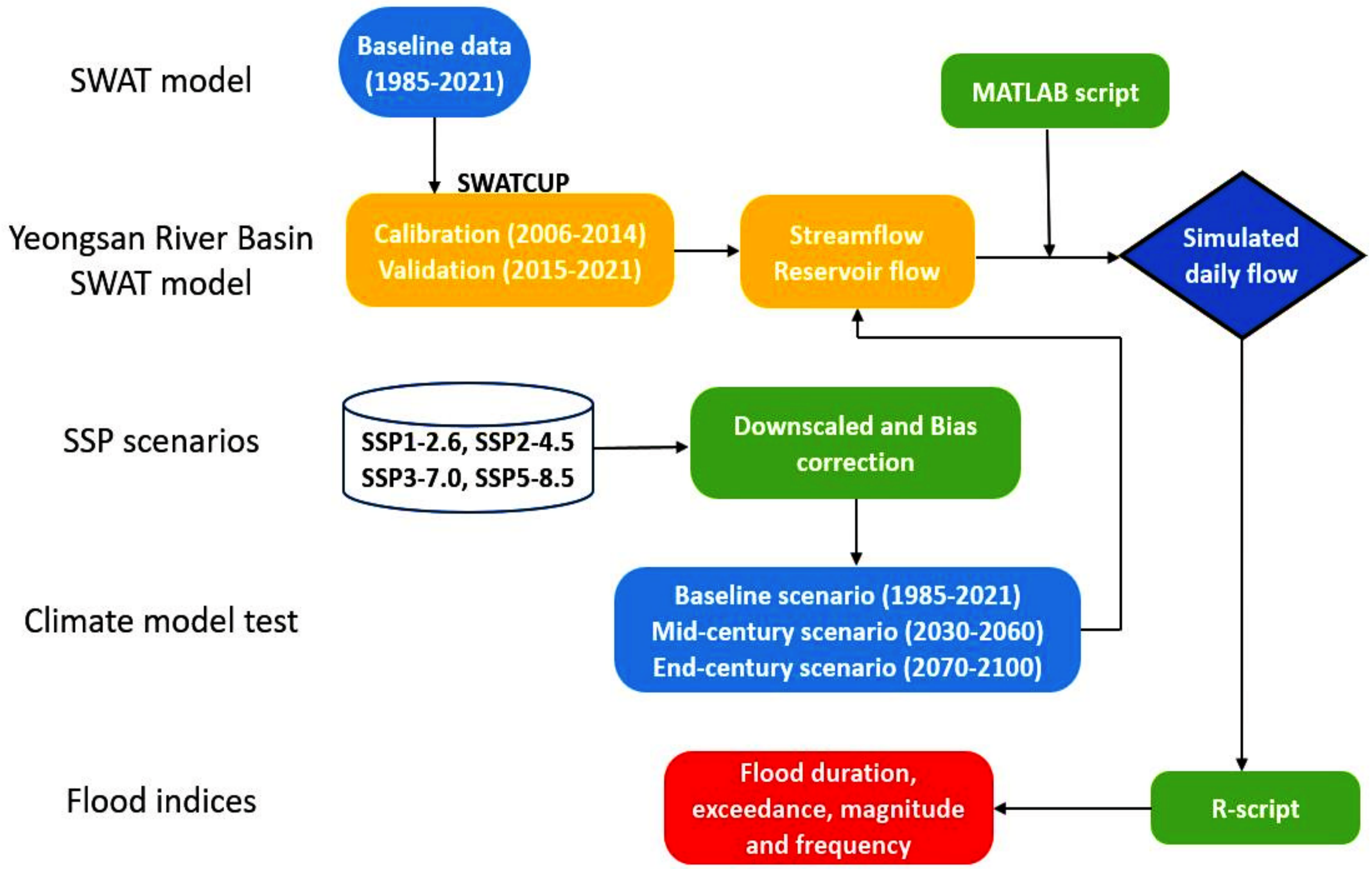


Fig. 7. Research flowchart.

3 Materials and methods

❖ SWAT Pre-processing Phase

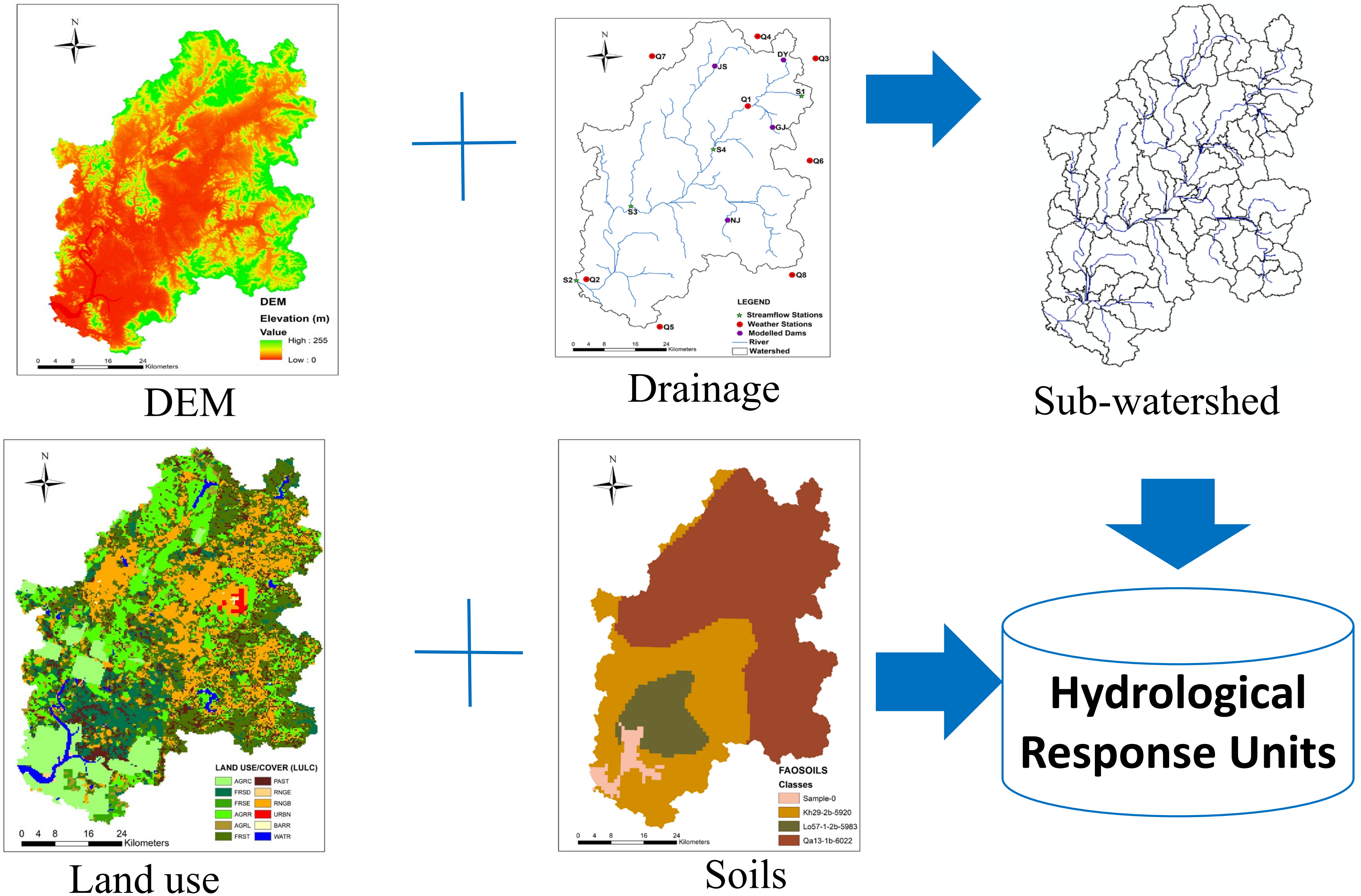


Fig. 8. SWMM flowchart.

3 Materials and methods

❖ Climate model downscaling and bias-correction

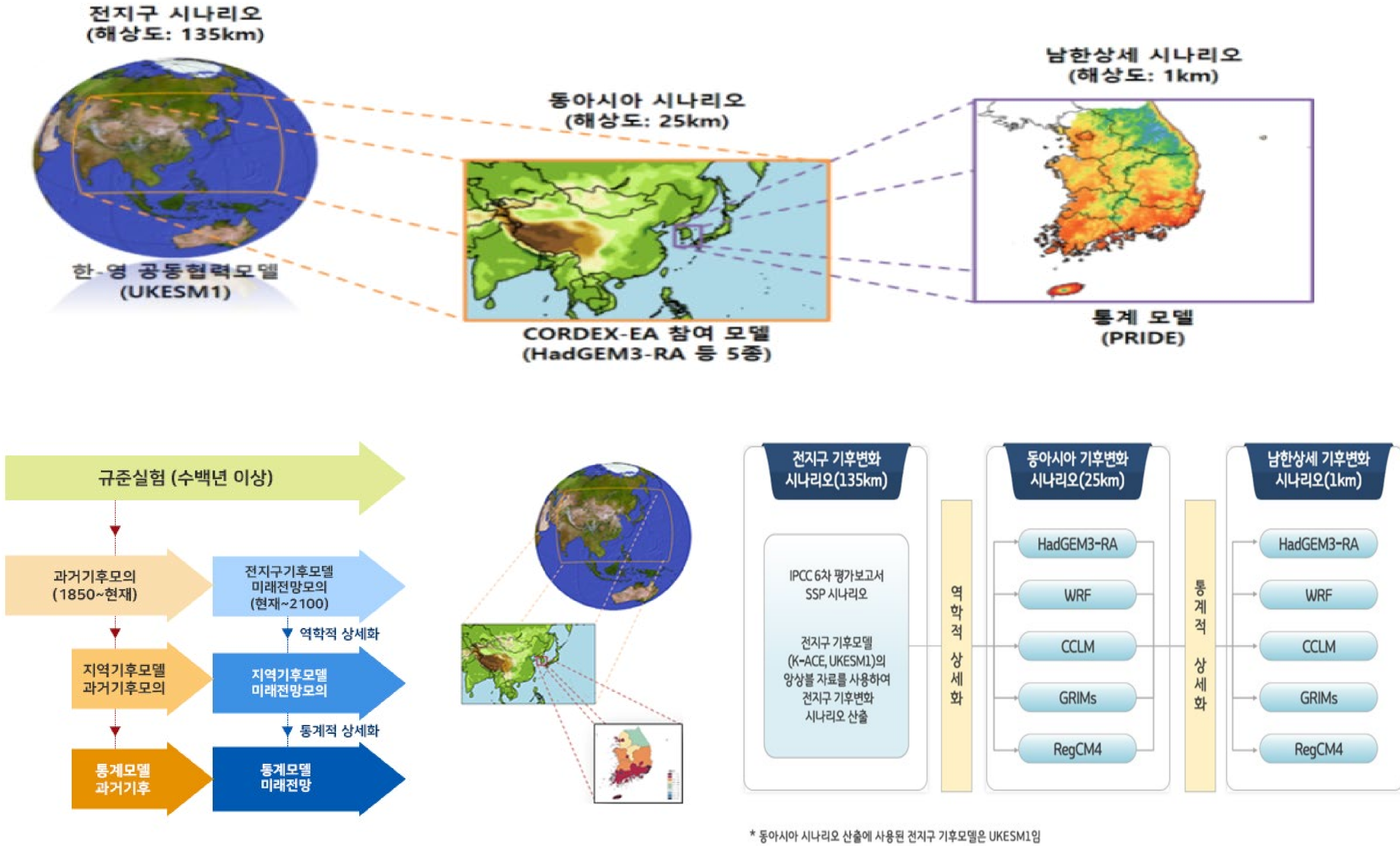


Fig. 9. Climate change downscaling and bias correction for the SSP scenario

3 Materials and methods

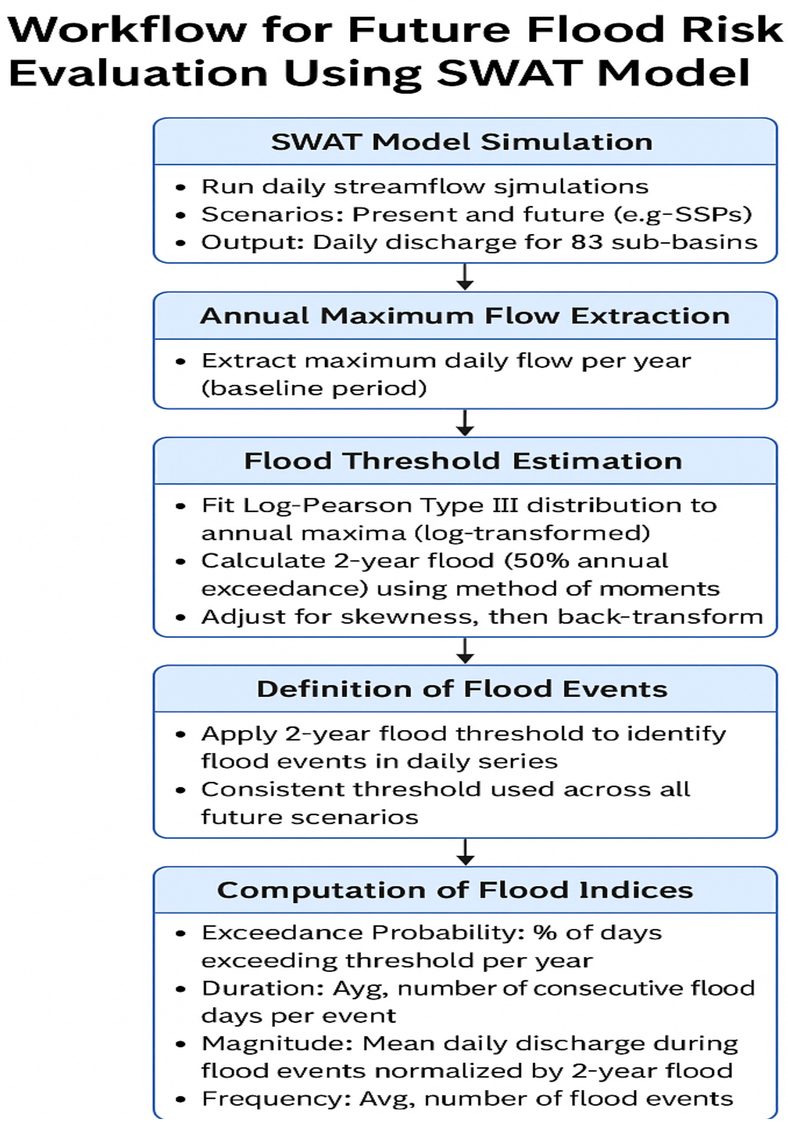


Fig. 10. Flood risk workflow

3 Materials and methods

❖ Flood indices Assessment

a) Flood exceedance probability index, $FEDI = \sum_{i=1}^{n} \frac{FED}{N} \times 100\%$

- Fraction of days in a water year with flow ≥ 2-year flood.
- Averaged across all years and expressed as a percentage.

b) Flood duration index, $FDI = \frac{\sum_{i=1}^{n} D_i}{N}$

- Calculated as the average number of consecutive flood days per event.
- Averaged across all flood events in a water year, then across all years.

c) Flood magnitude index, $FMI = \frac{Q_{peak}}{Q_{threshold}}$

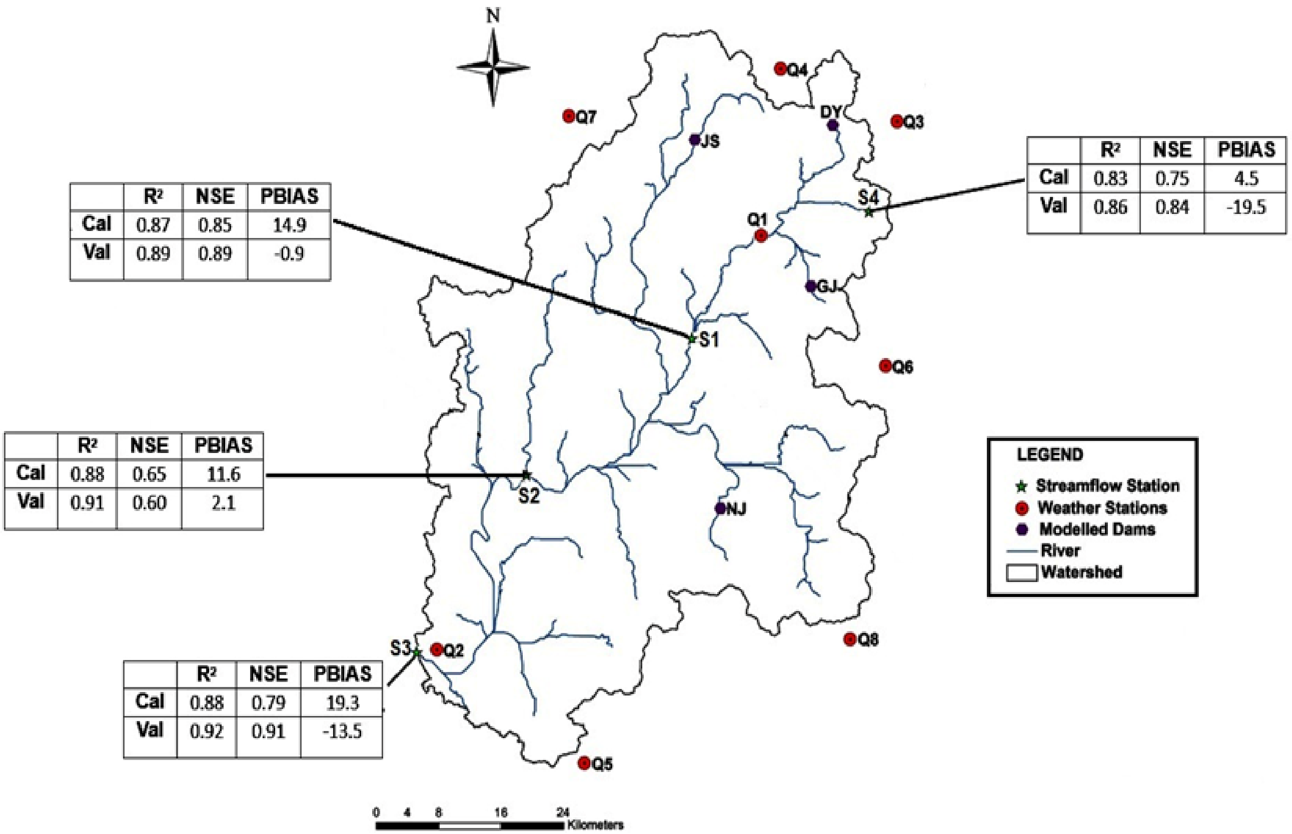
- Daily discharge averaged for each flood event.
- Event averages aggregated by water year, then across years.
- Final average normalized by the 2-year flood discharge per sub-basin.

d) Flood frequency index, $FFI = \frac{N_{flood}}{N}$

- Defined as the average number of flood events per water year.
- Computed over the full observation period.

4 Results and Discussion

❖ Model Calibration and validation



	R^2	NSE	PBIAS
Cal	0.87	0.85	14.9
Val	0.89	0.89	-0.9

	R^2	NSE	PBIAS
Cal	0.83	0.75	4.5
Val	0.86	0.84	-19.5

	R^2	NSE	PBIAS
Cal	0.88	0.65	11.6
Val	0.91	0.60	2.1

	R^2	NSE	PBIAS
Cal	0.88	0.79	19.3
Val	0.92	0.91	-13.5

Fig. 11. Calibration and validation of the SWAT model

The model's overall performance was satisfactory according to the criteria suggested by Moriasi et al., 2015.

4 Results and Discussion

❖ Results

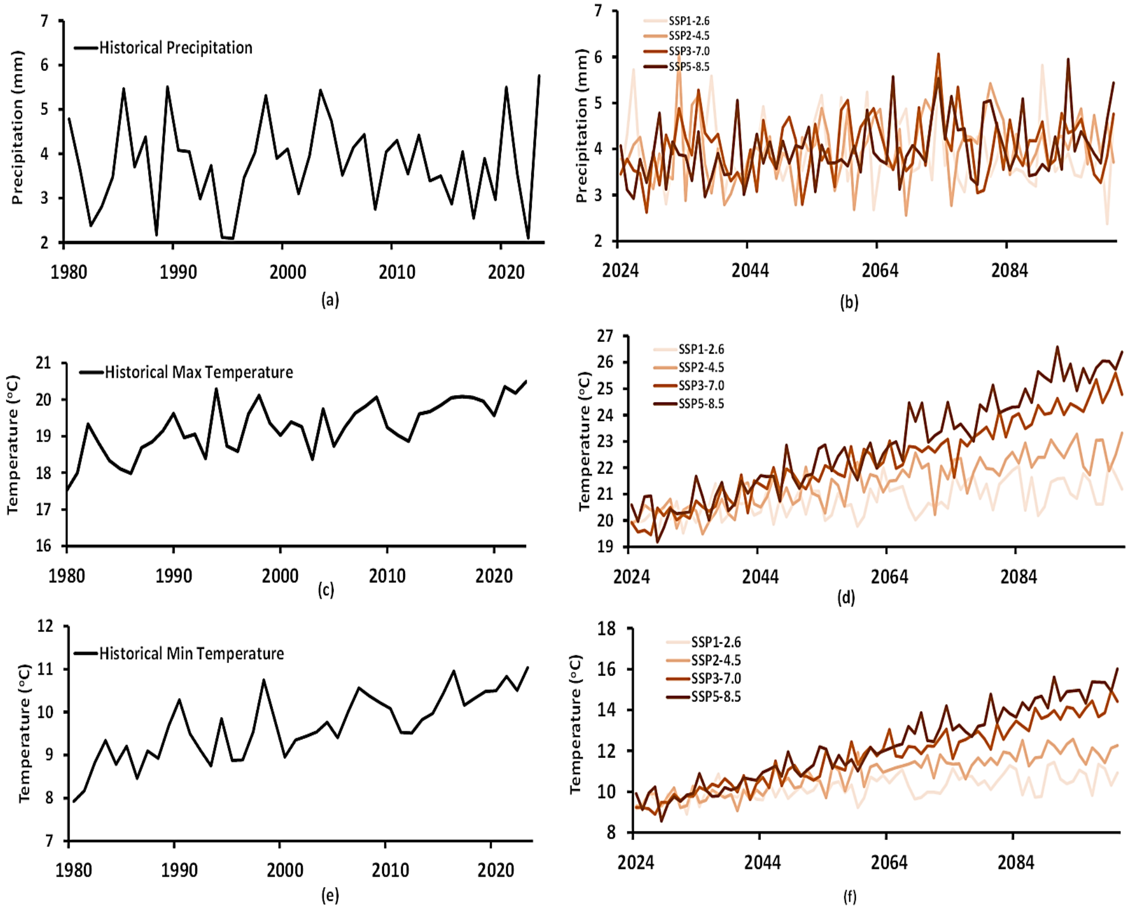


Fig 12. Average yearly precipitation, maximum temperature and minimum temperature

Under the SSP scenarios, precipitation increased approximately by 3.42% for the SSP1-2.6 scenario, and 5.52% for the SSP5-8.5 scenario.

Average yearly minimum and maximum temperatures increased between 1-4°C across all scenarios

4 Results and Discussion

❖ Baseline scenario results indicate that flood duration represents manageable but disruptive events for a 2-year return period.

❖ The flood duration lasted between 9 and 27 hours; flood exceedance indicates that a flood is expected to occur once every 2 years. Flood magnitude ranged from relatively minor flood to prolonged rainfall intensity leading to higher flow rates.

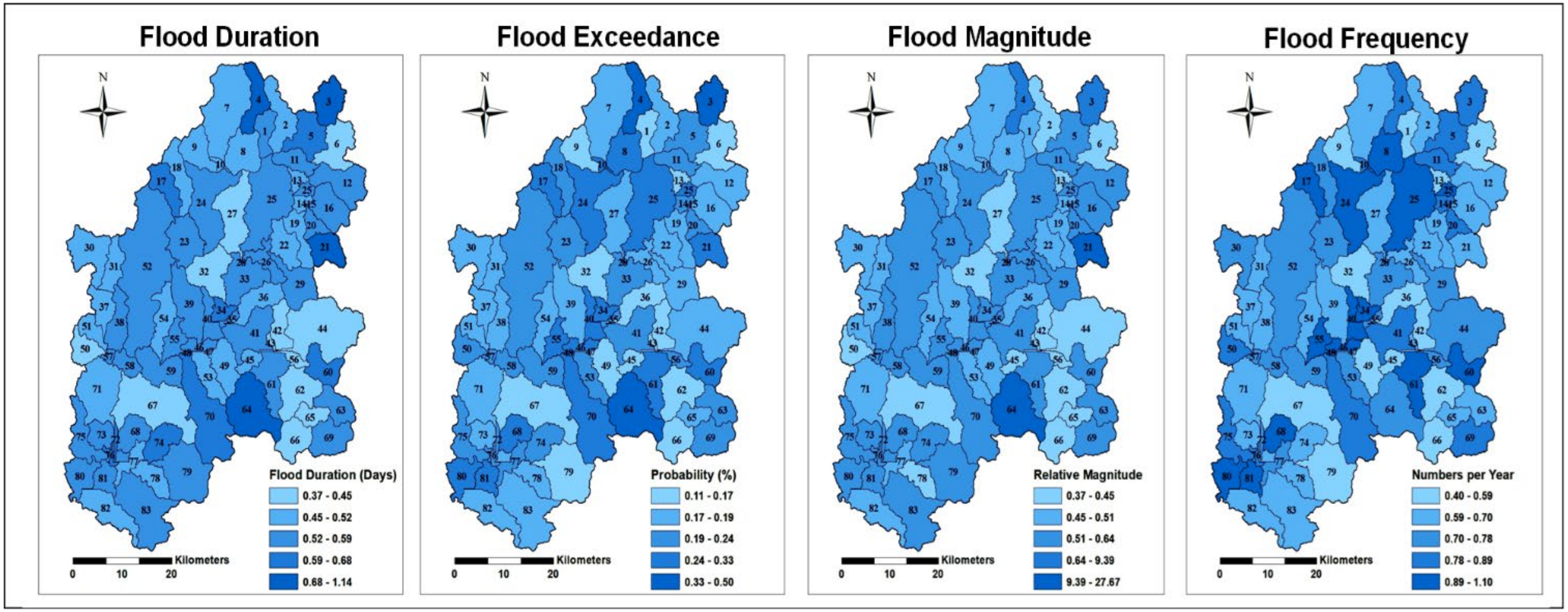


Fig 13. Flood risk at a 2-year flood recurrence threshold for four indices under the baseline scenario.

4 Results and Discussion

❖ Flood risk assessment for the SSP 1-2.6 Scenario (Mid and end century)

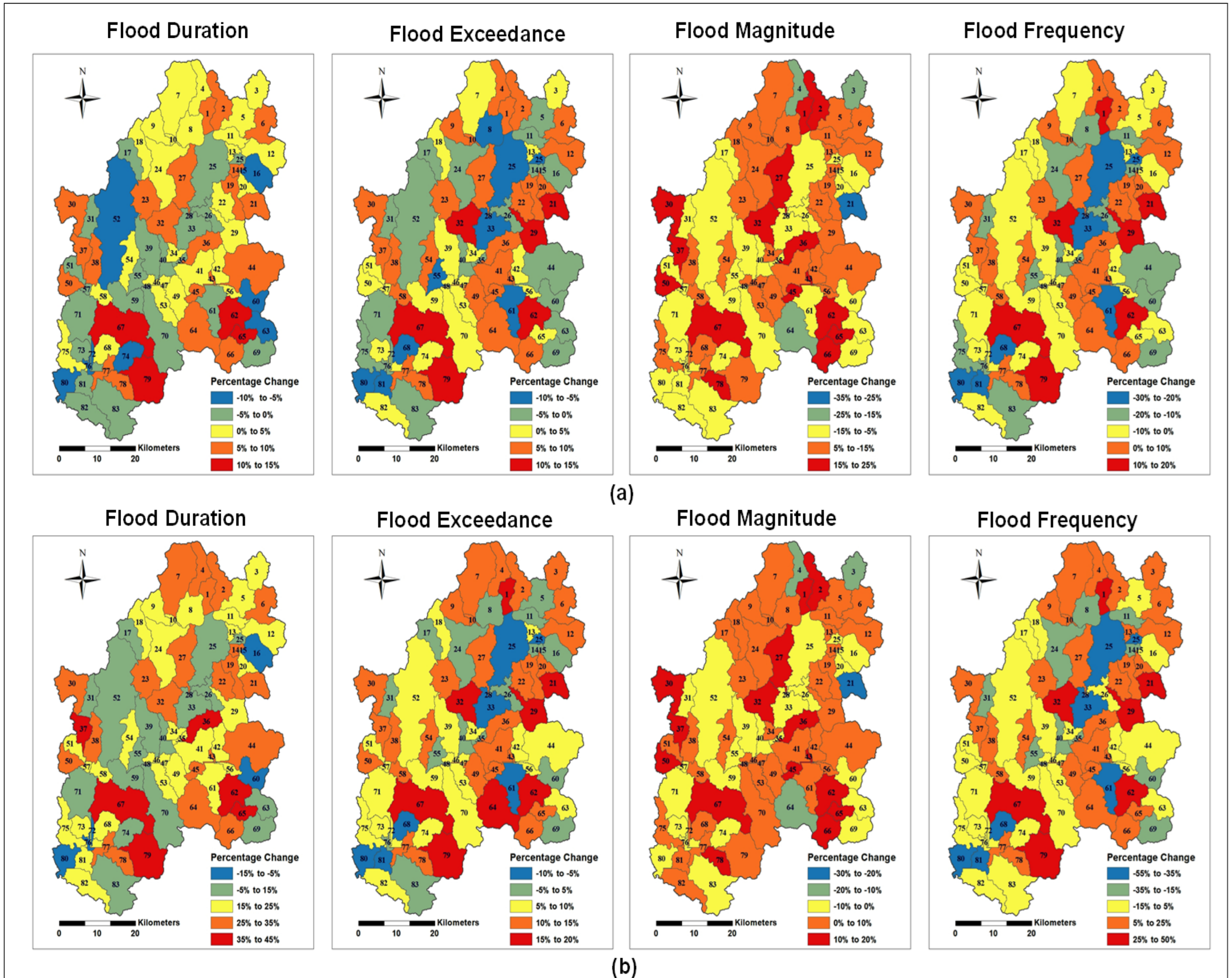


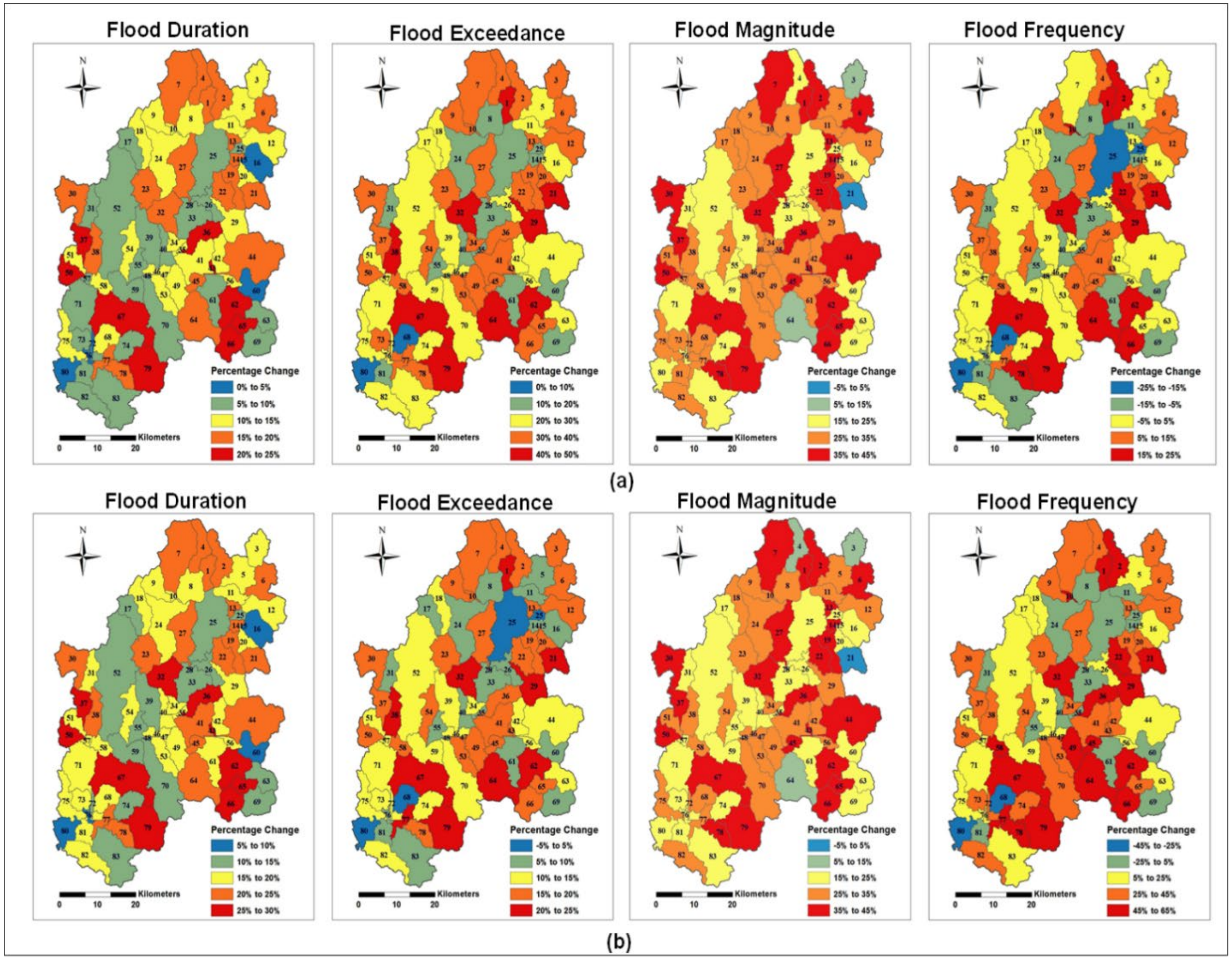
Fig 14. The percentage change between the Baseline and end-century SSP1-2.6 scenario.

In the SSP1-2.6 mid-century scenario, spatial distributions of the flood indices ranged between -35% to 30% across the sub-basins of the YRB.

In the SSP1-2.6 end-century scenario, spatial distributions of the flood indices ranged between -55% to 50% across the sub-basins of the YRB.

4 Results and Discussion

❖ Flood risk assessment for the SSP 5-8.5 Scenario (Mid and end century)



In the SSP5-8.5 mid-century scenario, spatial distributions of the flood indices ranged between -25% to 50% across the sub-basins of the YRB.

In the SSP5-8.5 end-century scenario, spatial distributions of the flood indices ranged between -45% to 65% across the sub-basins of the YRB.

Fig 15. The percentage change between the Baseline and end-century SSP5-8.5 scenario.

5 Conclusions

❖ The four indices showed higher risk in urban areas in the headwaters and lower risk in agricultural areas.

❖ Our findings suggest this watershed is likely to experience a reduction in flood risk under the mid-century scenario and a higher flood risk under the end-century scenario.

❖ Some regions may experience less frequent floods, reducing immediate risks, other areas may face much more frequent flooding, increasing pressure on flood defences and communities.

❖ One limitation of the study is that we used only 5 GCMs; if multiple GCMs can be used, it may improve the accuracy and credibility of impact analysis by capturing uncertainty.

❖ Adaptive planning, improved flood risk management, and resilient infrastructure will be critical to coping with the evolving flood patterns in a changing climate.

Q & A

Email: bateashu@snu.ac.kr

서울대학교 그린인프라공학연구실
Green Infrastructure Engineering Lab

서 울 대 학 교
SEOUL NATIONAL UNIVERSITY

Soil & Water Assessment Tool | SWAT