Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 9-10, 2024

Rainfall-runoff Assessment at NPP Site Based on Climate Change Scenarios

Beom-jin Kim[1*], Minkyu Kim[1]
[1]*Strctural and Seismic Safety Research Division, Korea Atomic Energy Research Institute*
[*]*Corresponding author: beomjin88@kaeri.re.kr*

***Keywords:** Climate change, Representative Concentration Pathways (RCP), Shared Socioeconomic Pathways (SSP), Rainfall-runoff, Flood analysis.

1. Introduction

Due to the influence of recent climate change, typhoon invasions of the Korean Peninsula with extreme rainfall frequently occur. Between August and September 2020, three typhoons, Bavi, Maysak, and Haishen, attack the Korean Peninsula, and the resulting heavy rains that fell caused flood damage. As typhoons Maysak and Haishen passed east of Korea, the local nuclear power plants were automatically shut down.

In this study, First, referring to the IPCC report, probability precipitation was estimated using the Representative Concentration Pathways (RCP) and Shared Socioeconomic Pathways (SSP) scenarios[1][2]. Second, the nuclear power plant basin was divided into sub-basins according to drainage flow. Finally, rainfall-runoff analysis was performed for each climate change scenario. Consequently, rainfall runoff from nuclear power plants was evaluated and presented according to changes in climate change scenarios.

2. Methods and Results

This study's rainfall-runoff analysis was performed according to climate change scenarios RCP and SSP. The local frequency analysis method was applied to estimate the probabilistic precipitation. And the worst scenarios, RCP8.5 and SSP5-8.5, were applied to the climate change scenario. In the rainfall-runoff analysis, runoff analysis by sub-basin was performed using HEC-HMS[3].

2.1 Probabilistic precipitation estimation

The R13 region containing the Ulsan precipitation point closest to the target area was selected to estimate the probabilistic precipitation. Afterward, the regional frequency analysis technique was applied. Climate change RCP8.5 and SSP5-8.5 scenarios were applied to the regional frequency analysis results to estimate the probabilistic precipitation for a 10,000-year return period. The GEV probability distribution suggested for use in the domestic 'Standard Guidelines for Flood Estimation (2019)' was applied to estimate probabilistic precipitation[4]. Finally, the probabilistic precipitation according to the climate change scenario was estimated as follows.

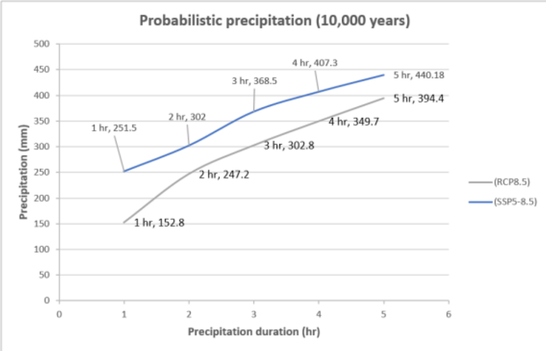

Fig. 1. Estimation of probabilistic precipitation

Table 1. Comparison of probabilistic precipitation

Probabilistic precipitation (10,000 years)					
Duration (hr)	1	2	3	4	5
Precipitation (RCP8.5)(mm)	152.8	247.2	302.8	349.7	394.4
Precipitation (SSP5-8.5)(mm)	251.5	302.0	368.5	407.3	440.18
Increase (mm)	98.7	54.8	65.7	57.6	45.78

2.2 Sub-basin classification

The Gori site was divided into three basins for rainfall-runoff analysis, and the Shin-Gori site was divided into four basins. Basins were classified based on drainage flow through digital maps, satellites, and workdown to classify sub-basins.

Fig. 2. Sub-basin of Gori site

Fig. 3. Sub-basin of Shin Gori site

2.3 Rainfall-runoff analysis

HEC-HMS, provided free of charge by the U.S. Corps of Engineers, was used for rainfall-runoff analysis. The Huff methodology was applied to derive the temporal distribution of probabilistic precipitation[5]. Rainfall-runoff analysis for rainfall durations from 1 to 5 hours at the site revealed that the peak flow was highest at 2 hours for the RCP scenario and 1 hour for the SSP scenario. Also, the Clark unit method presented in the 'Standard Guidelines for Flood Estimation (2019)' was applied to estimate floods[4].

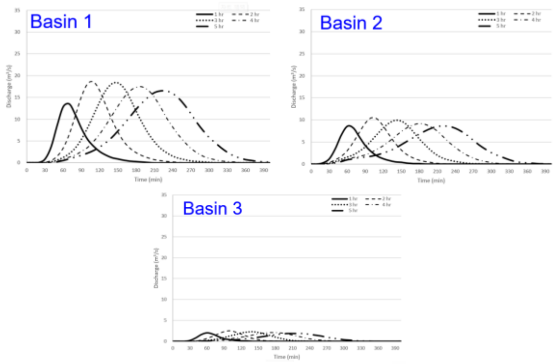

Fig. 4. Rainfall-runoff analysis result for RCP8.5

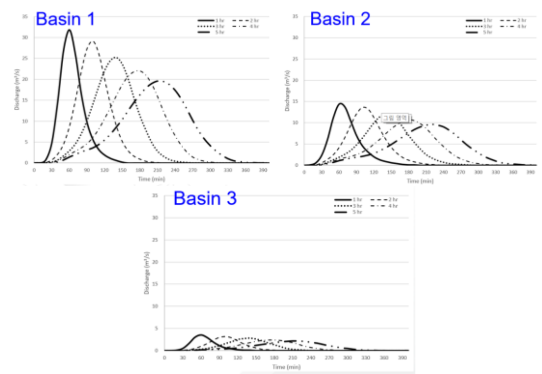

Fig. 5. Rainfall-runoff analysis result for SSP5-8.5

2.4 Result of rainfall-runoff analysis

According to climate change scenarios, rainfall-runoff analysis estimated that the runoff outflow by basin was more significant in the SSP scenario than in the RCP scenario.

Table 2. Result of rainfall-runoff

	Point	Rainfall-runoff analysis (1hr) [m^3/s]		Increase/decrease compared to RCP	
		SSP5-8.5	RCP8.5	Difference between SSP5-8.5 and RCP8.5 decrease	Rate (%) (difference / RCP8.5)
Gori	Basin 1	31.8	13.5	-18.3	135.56
	Basin 2	14.4	8.6	-5.8	67.44
	Basin 3	3.5	2	-1.5	75
Shin Gori	Basin 1	8	4	-4	100
	Basin 2	8.9	4.6	-4.3	93.48
	Basin 3	22.5	11.9	-10.6	89.08
	Basin 4	23.7	13	-10.7	82.31

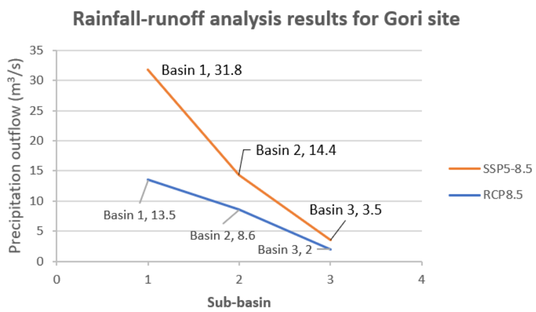

Fig. 6. Comparison of climate change scenarios for Gori site

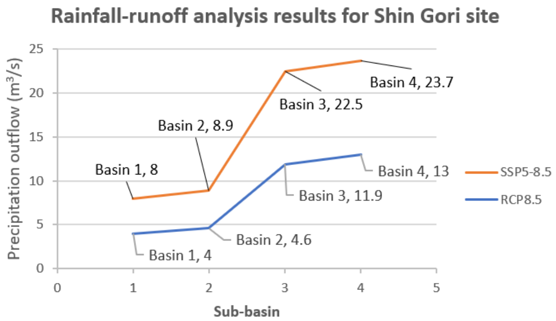

Fig. 7. Comparison of climate change scenarios for Shin Gori site

3. Conclusions

This study assessed the impact of rainfall-runoff at a nuclear power plant site under a climate change scenario. As a result, it was confirmed that the SSP scenario presented in the IPCC 6th report had more runoff outflows than the existing RCP scenario. Based on the results of this study, we plan to conduct flood impact assessments according to climate change scenarios through flooding analysis at nuclear power plant sites in the future.

Acknowledgments

This research was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT) (No. RS-2022-00144493).

REFERENCES

[1] Korea Meteorological Administration, IPCC 5th Report
[2] Korea Meteorological Administration, IPCC 6th Report
[3] HEC-HMS, US Army Crops of Engineers Hydrologic Engineering Center.
[4] Ministry of Environment (2019), Standard guidelines for flood estimation.
[5] S. Choi, G. Joo, H. Shin, and J. Heo. (2014). Improvement plan for Huff's quartile method considering heavy rain events. Journal of the Korean Society of Water Resources, 47(11), 985-996.