TA-124L

ASSESSING FLOOD INUNDATION IN THE LOWER PREK THNOT RIVER BASIN UNDER CLIMATE CHANGE USING RRI MODEL COUPLED WITH SWAT

Sophea Rom Phy[1], Sophal Try[2], Ty Sok[1,3,*], Ilan Ich[1], Chantha Oeurng[1]

[1] Faculty of Hydrology and Water Resources Engineering, Institute of Technology of Cambodia

[2] Disaster Prevention Research Institute, Kyoto University

[3] Research and Innovation Center, Institute of Technology of Cambodia, Phnom Penh, Cambodia
*Corresponding author: E-mail: sokty@itc.edu.kh

Keywords: Climate change, Flood inundation, Lower Prek Thnot River Basin

Introduction

Flooding has become more frequent and intense due to climate change (CC), in which changes in precipitation, hydrology, and flooding attributes are inevitable. Investigation of flooding under certain scenarios is by and large done through hydrodynamic modelling. Yet, the integration between the Soil and Water Assessment Tool (SWAT) model (Neitsch et al., 2011) and the Rainfall-Runoff-Inundation (RRI) model (Sayama et al., 2015) has not been explored yet. Thus, the study seeks to combine both models and determine percentage changes in extreme discharge and flood inundation of a possible flood event in the 2030s (2021-2040) and 2060s (2051-2070) under RCP2.6 and RCP8.5 in the lower Prek Thnot River Basin (Fig 1), where much attention is given due to its high vulnerability to flash flooding during the high rainfall events in October, average annual rate of which is 1,225 mm. The basin has so far incurred maximum flood discharges up to 1,371 m^3/s.

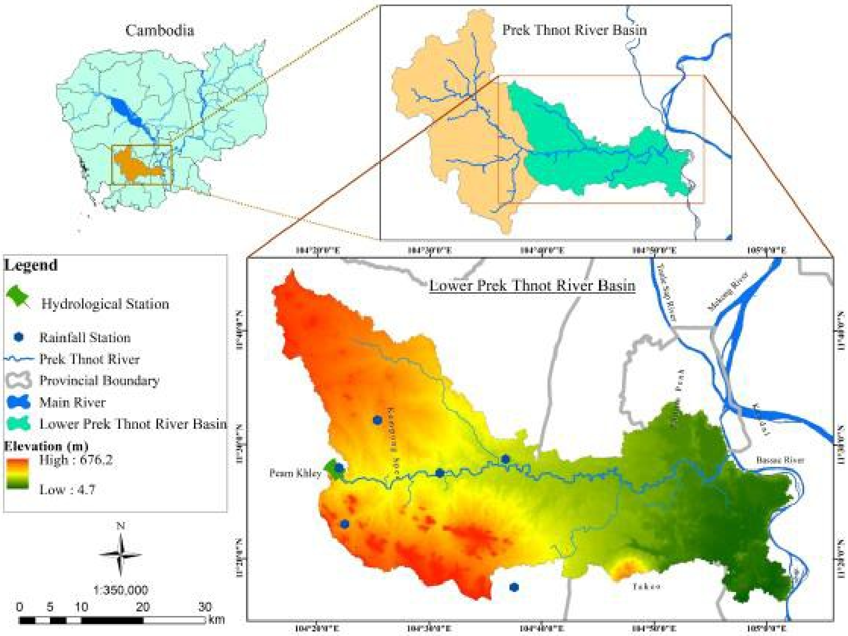

Fig 1. Map of the lower Prek Thnot River Basin

Method

The RRI model, a two-dimensional fully distributed hydrodynamic model, was deployed and set up at spatial resolution of 500 m at a daily time-step from September to November. The simulated baseline and CC daily discharges from SWAT run over the Prek Thnot River Basin were extracted at Peam Khley station to be inputted as the inflow boundary condition for the lower basin using RRI. The worst and peak flood event in 2000 was selected as the baseline. Before running the CC scenarios, the model accuracy was conducted in which 2000, 2001 and 2010 flood events were calibrated and validated. Observed and simulated discharge and flood maps were compared and all deemed acceptable, using the performance indices (NSE, PIBIAS, RSR, R^2 for discharge; True Ratio, Hit Ratio for flood map).

The CC's rainfall was derived from downscaled monthly 'change factors' acquired from the Mekong River Commission Climate Change and Adaptation Initiative (MRC, 2018). The MRC's recommended three General Circulation Models (GCMs), namely the wetter overall GFDL-CM3, the drier overall GISS-E2-R-CC, and the increased seasonal variability IPSL-CM5A-MR, were used.

Results and Discussion

Table 1. Changes (%) of Qm and Q5 under CC

	GCMs	Scenarios	*Qm (%)	**Q5 (%)
2030s	GFDL-CM3	RCP2.6	4.5	3.9
		RCP8.5	11.3	8.4
	GISS-E2-R-CC	RCP2.6	-7.5	-8.4
		RCP8.5	-34.8	-21.4
	IPSL-CM5A-MR	RCP2.6	0.4	1.7
		RCP8.5	-10.6	4.2
2060s	GFDL-CM3	RCP2.6	3.4	3.1
		RCP8.5	19.7	13.5
	GISS-E2-R-CC	RCP2.6	-5.4	-6.4
		RCP8.5	-45.2	-39.3
	IPSL-CM5A-MR	RCP2.6	0.8	1.3
		RCP8.5	-13.9	-1.6

*Baseline Qm =86.5 m^3/s **Baseline Q5 = 675.5 m^3/s

Overall, the mean discharges (Qm) were bound to change more drastically under RCP8.5, the highest change of which occurred in the 2060s, using the GFDL and GISS scenarios (Table 1). The river flow exceeding 5% of the time (Q5) would change modestly in the 2030s and twice as much in the 2060s, especially under RCP8.5, compare with the baseline. The highest changes in Q5 were over 13.5% and -39.3%, respectively in the 2060s. Increases in Q5 imply intensifying flooding.

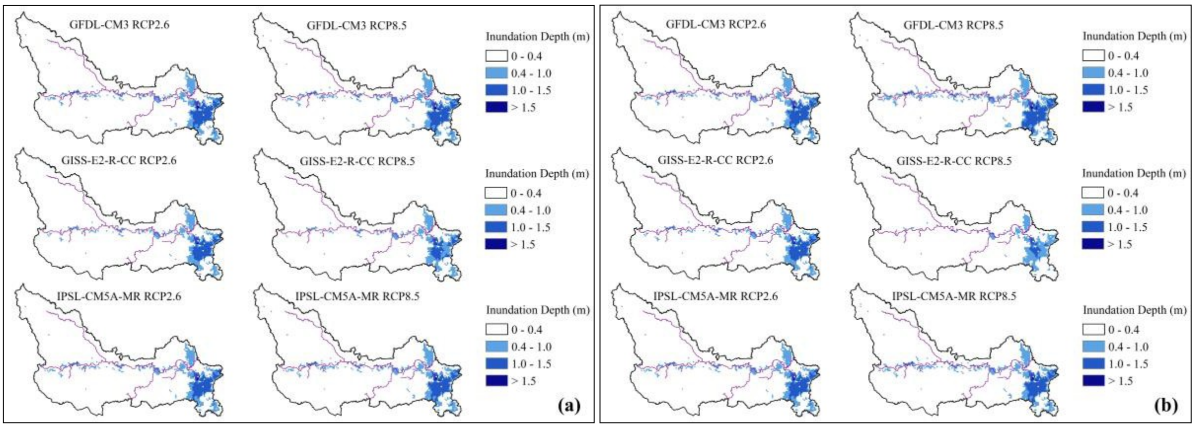

Fig 2. Flood Extent and Depth for All GCMs in the (a) 2030s and (b) 2060s

Table 2. Magnitude and Percentage Change of Inundated Areas in the (a) 2030s and (b) 2060s

	GCMs	Scenarios	Inundated Areas*
2030s	GFDL-CM3	RCP2.6	201 *(+2.3%)*
		RCP8.5	207.75 *(+4.7%)*
	GISS-E2-R-CC	RCP2.6	186 (-5.3%)
		RCP8.5	173 *(-12%)*
	IPSL-CM5A-MR	RCP2.6	198.25 *(+0.9%)*
		RCP8.5	211 *(+7.4%)*
2060s	GFDL-CM3	RCP2.6	200 *(+1.8%)*
		RCP8.5	237.25 *(+20.7%)*
	GISS-E2-R-CC	RCP2.6	186.75 *(-5%)*
		RCP8.5	134.75 *(-31.4%)*
	IPSL-CM5A-MR	RCP2.6	197.75 *(+0.6%)*
		RCP8.5	221.5 *(+12.7%)*

*Baseline inundated areas: 196.5 km^2

Floods would be severer given a larger extent with depth > 1 m as predicted by the GFDL scenario under RCP8.5-2060s (Fig 2). Changes in flooded areas for all models were marginal under RCP2.6 (Table 2). Under RCP8.5-2060s, the changes were significant (20.7% and -31.4%, as per the GFDL and GISS scenarios, respectively). On top of that, flood depth > 1 m would cover the largest areas of 82 km^2 (about +30%) under the GFDL scenario under RCP8.5-2060s (Fig 3).

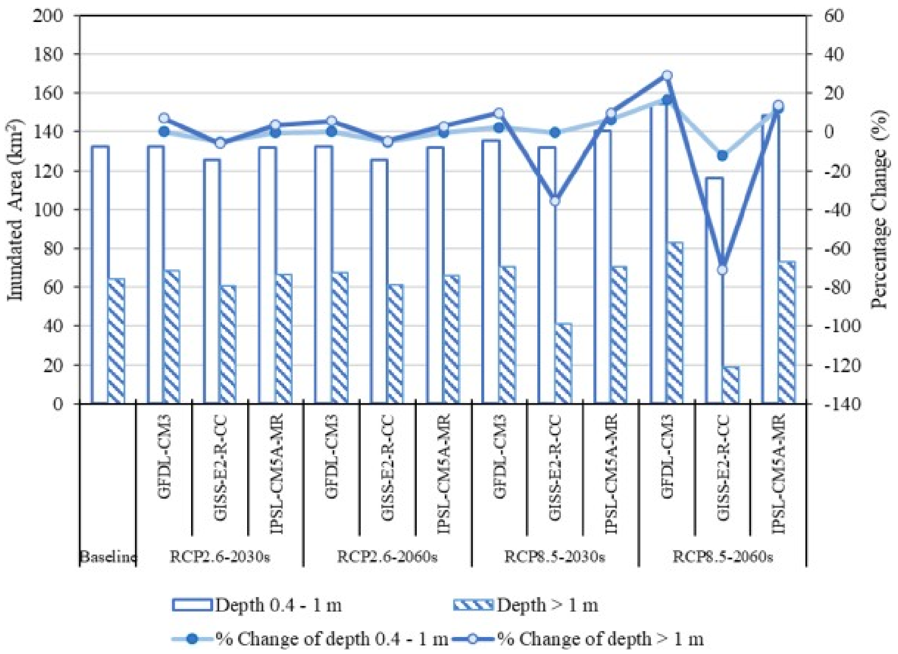

Fig 3. Magnitude and Percentage Change in Inundated Area with Classified Flood Depth

Overall, the volatility of change in discharge and flood magnitude stemmed from the difference of GCMs, scenarios, and time horizons. Moreover, if the climate mitigation strategies are not stringent enough, the outputs under RCP8.5, in which changes are large and significant, should be considered, and vice versa for RCP2.6.

Conclusions

Climate change impacts on flooding were examined through the model integration. The extreme flow and flooding will be intensified using the GFDL and IPSL, and less severe using the GISS scenarios, particularly under RCP8.5 during both periods. These outputs can be used to assist in future forecasting and watershed management.

Acknowledgements
This study was funded by the Cambodia Higher Education Improvement Project (Credit No. 6221-KH).

References

MRC, 2018. Basin-Wide Assessment of Climate Change Impacts on Hydropower Production.

Neitsch, S.L., Arnold, J.G., Kiniry, J.R., Williams,J.R., 2011. Soil and water assessment tool theoretical documentation version 2009.

Sayama, T., Tatebe, Y., Iwami, Y., Tanaka, S., 2015. Hydrologic sensitivity of flood runoff and inundation: 2011 Thailand floods in the Chao Phraya River basin. Nat. Hazards Earth Syst. Sci. 15, 1617–1630. https://doi.org/10.5194/nhess-15-1617- 2015