Climate Change Impacts on Extreme Flood Inundation in the Lower Mekong Basin

○Sophal Try, Shigenobu Tanaka, Kenji Tanaka, Takahiro Sayama

Introduction

Climate change has become one among the global concerns and is currently affecting the resilience of the aquatic ecosystem worldwide. The Mekong River Basin (MRB) is located in the prone area vulnerable to climate change impact driving a great change in characteristics of river hydrology and downstream flood inundation (Fig. 1).

This study aims to evaluate the impact of climate change impact on extreme flood inundation in the Lower Mekong Basin (LMB).

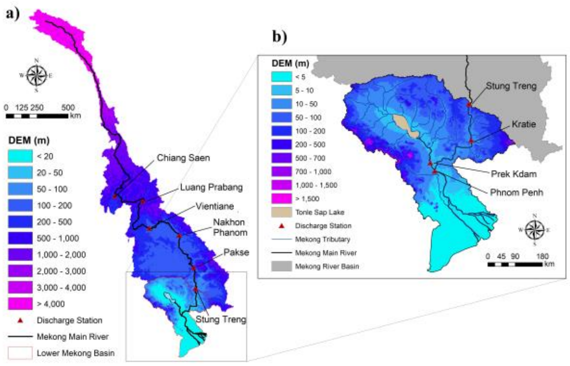

Fig. 1 Location of the MRB (a) and the LMB (b)

Method and Dataset

This study used a fully distributed rainfall-runoff and inundation (RRI) model based on 2D diffusive wave equations to simulate surface and subsurface flow in the mountainous region and Green-Ampt infiltration in the floodplain. The RRI model is used to simulate river discharge and flood inundation in the LMB.

To evaluate the effects of climate change on flood characteristics, we considered the outputs from the high-resolution and super-high-resolution AGCMs (MRI-AGCM3.2S and MRI-AGCM3.2H) during the present climate (1979-2003) and future climate (2075-2099).

To examine the changes in magnitude of extreme flood inundation events in the LMB, we used a database for policy-making for future climate change (d4PDF) projected under the future 4 K warming scenario. The d4PDF dataset has 100 ensemble members in the present experiment during 1951-2010 (60-year × 100 members) and 90 ensemble members for the future climate in 2051-2110 (60-year × 90 members) considering six sea surface temperature patterns namely as CC, GF, HA, MI, MP, and MR.

Results

The results of climate change suggested that flood magnitude in the LMB will be severer than the present climate by the end of the twenty-first century. The frequency and magnitude of inundation in the LMB will be severer at the end of the 21st century for all future (RCP and SST). There will be no significant change in terms of flood time (DOY).

The increase of annual precipitation (6.6-14.2%) could force to enlarge the extreme high flow (Q_5) 13-30%, inundation area 19-43%, inundation volume 24-55% in the LMB for ranging of RCP and SST scenarios. Different RCP scenario has a greater variation of changes than different SST scenario for future inundation in the LMB. The area with a long flood duration corresponds with a high probability of flood inundation (Try et al., 2020a).

Fig. 2 showed changes in inundation probability and inundation duration with statistical Kolmogorov-Smirnov (K-S) test.

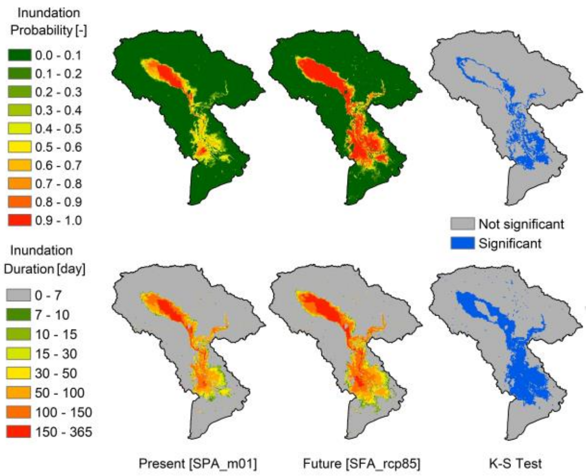

Fig. 2 Comparison of probability and duration of flood inundation from present (1979-2003) to future (2075-2099) climate with K-S test from MRI-AGCM3.2S model

The results indicated that 90-day precipitation counting backward from the day of peak flooding has the highest correlation with peak river discharge and inundation volume in the LMB. The probability of 90-day precipitation of d4PDF dataset significantly shifted with a large variation of the mean (from 777 mm to 900 mm) and standard deviation (from 57 mm to 96 mm) from the present to the future climate.

Different patterns of sea surface temperature significantly influence the variation of precipitation and flood inundation in the LMB in the future (2051–2110).

The magnitude of flood inundation of 1:50-, 1:100-, and 1:1000-year flood events increased from present to future climate experiments (Fig. 3). The peak discharge at Kratie in the present was 61,588, 67,400, and 84,762 m^3/s for 1:50-, 1:100-, and 1:1000-year events; these values drastically rose to 77,103 m^3/s (+25%), 89,331 m^3/s (+33%), and 118,912 m^3/s (+40%) in the future (Try et al., 2020a). Moreover, the magnitudes of the extreme events in 50, 100, and 1,000 years would increase by +19%, +29%, +36% for inundation extent and +23%, +34%, +37% in terms of inundation volume in the future, respectively.

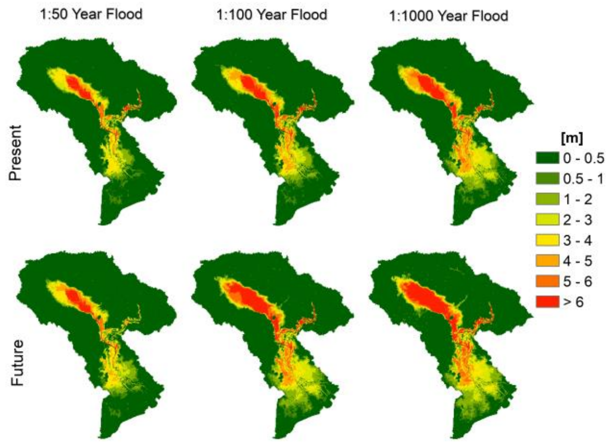

Fig. 3 Comparison of extreme flood events (50-year, 100-year, and 1000-year return period) for present and future climate experiments.

Conclusion

This study provided additional information on climate change impacts on flood inundation. The results revealed the significant increase of flood inundation in the MRB under various projected scenarios of future climate change effects considering high-resolution and large ensemble climate outputs. Therefore, it is important to prepare climate change adaptation as well as flood damage reduction strategies in this region.

Reference

Try S., Tanaka S., Tanaka K., Sayama T., Lee G., Oeurng C. (2020a). Assessing the effects of climate change on flood inundation in the Lower Mekong Basinusinghigh-resolution AGCM outputs.Progress inEarth and Planetary Science, 7(34). doi: 10.1186/s40645-020-00353-z.

Try S., Tanaka S., Tanaka K., Sayama T., Hu M., Sok T., Oeurng C. (2020b). Projection of extreme flood inundation in the Mekong River Basin under 4 K increasing scenario using large ensemble climate data. Hydrological Processes, 1-15. doi: 10.1002/hyp.13859..