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# Flood hazard assessment under climate change scenarios in the Yang River Basin, Thailand

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**Abstract**

Climate change is expected to increase both the magnitude and frequency of extreme precipitation events, which may lead to more intense and frequent river flooding. This study aims to assess the flood hazard potential under climate change scenarios in Yang River Basin of Thailand. A physically-based distributed hydrological model, Block-wise use of TOPMODEL using Muskingum-Cunge flow routing (BTOPMC) and hydraulic model, HEC-RAS was used to simulate the floods under future climate scenarios. Future climate scenarios were constructed from the bias corrected outputs of three General Circulation Models (GCMs) for 2020s, 2050s and 2080s. Results show that basin will get warmer and wetter in future. Both the minimum and maximum temperature of the basin is projected to increase in future. Similarly average annual rainfall is also projected to increase in future, higher in near future and lower in far future. The extreme runoff pattern and synthetic inflow hydrographs for 25, 50 and 100 year return flood were derived from an extreme flood of 2007 which were then fed into HEC-RAS model to generate the flood inundation maps in the basin. The intensity of annual floods is expected increase for both RCP 4.5 and 8.5 scenarios. Compared to the baseline period, an additional 60 $km^2$ area of basin is projected to be flooded with the return period of 100 years. The results of this study will be helpful to formulate adaptation strategies to offset the negative impacts of flooding on different land use activities in Yang River Basin.


*Keywords:* Climate change; RCP scenarios; Flood hazard; Thailand; Hydrological modeling; Hydraulic modeling

## 1. Introduction

Yang River Basin is one of the most flood prone basins in Northeast Thailand (Kuntiyawichai et al., 2011a,b). Several studies on climate change impact assessment and flood management strategies have been conducted on its main basin, Chi River Basin, in recent years (Chaleeraktrakoon and Khwanket, 2013; Artlert et al., 2013; Kuntiyawichai et al., 2011a,b). These studies reported that climate change is consistent and it has strong implications on the basin scale hydrological cycle. Other studies done globally indicate the altercated meteorological variables have great potential to change the frequency and intensity of extreme events specially floods (Dobler et al., 2012; Viviroli et al., 2011). The increase in temperature accelerates the evapotranspiration process which further influences the

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precipitation amount and ultimately contributes in modification of seasonal runoff. The present intra-annular variability in the amount of runoff is expected to shift under climate change scenarios at many regions of the world including Thailand (Dobler et al., 2010).

In addition to the projected changes in the hydrological regime, the climate change will also have implications on the extreme events. Studies have demonstrated that flood intensity is highly sensitive to temperature in many parts of the world (Prudhomme et al., 2013; Menzel et al., 2002; Panagoulia and Dimou, 1997). Several other studies also have argued that climate has been a contributing factor to flood risk by raising the precipitation amount relative to the average annual rainfall (Fleming et al., 2012; Hirabayashi et al., 2008). Therefore, basin scale assessment of climate change impacts on flood plays a key role in formulation and evaluation of adaptation and mitigation strategies for flood risk management.

Literature suggests that climate change impact assessment on extreme events has been less investigated and possesses higher uncertainty (Dobler et al., 2012). In addition, whatsoever the research has been conducted, primary focus is on the basin of developed nations (Bauwens et al., 2011; Prudhomme et al., 2010; Steele-Dunne et al., 2008). Also focusing on Asian countries, many studies on floods induced by climate change have been conducted on several basins in China (Li et al., 2013; Zheng et al., 2012; Yang et al., 2012). This implies less focus on basins of developing countries lying on the tropical regions which are evidently more susceptible to floods where the region has already high precipitation and the hydrologic cycle is highly interlinked and sensitive to its components (Kite, 2001). Although considerable studies on floods have been conducted in Northeast of Thailand yet only few of studies were on the impact of climate change on extreme events (Jothityangkoon et al., 2013; Hunukumbura and Thailand, 2012). Despite several flood events in Yang River Basin most of the studies focused on the management practices and socio-economic impacts of floods (Keokhumcheng et al., 2012; Dutta, 2011; Hungspreug et al., 2000). Shrestha (2014) studied the climate change impact on flood hazard potential in Yang River Basin. However, the study used the climate change projections from Special Report on Emission Scenarios (SRES) and only one Regional Climate Model, which poses greater uncertainty in flood hazard assessment. Hence the basin scale study of climate change impact on flood hazard using future climate data from multiple climate models and new emission scenarios is important in Thailand.

Another important factor that has decisively influenced the climate change impact studies is the use of Global Circulation Models (GCMs) and Regional Climate Models (RCMs) dataset for the future climate projection without bias correction (Cloke et al., 2013). Although RCMs perform nested dynamic downscaling to the outputs of the General Circulation Models (GCMs), yet the spatial resolution makes the data unreliable for basin scale impact assessment studies and is necessary to be bias corrected (Muerth et al., 2013). A few studies have been conducted so far on analysis of different downscaling techniques with emphasis on extreme events. A comparison study of six downscaling technique with three RCMs suggests both statistical and dynamic downscaling tends to have similar bias. However, the choice of method of downscaling depends on variables to be downscaled (Schmidli et al., 2007). Leander and Buishand (2007) satisfactorily used the power law transformation method for RCM outputs at Western Europe for estimation of extreme events.

Many studies have adopted various climate change scenarios to evaluate these effects. The scenarios presented in the Special Report on Emission Scenarios (SRES) in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4) (IPCC, 2007) have been widely applied to investigate hydrological responses to climate change (Praskievicz and Chang, 2011; Moradkhani et al.; 2010; Ficklin et al., 2009; Tu, 2009; Yoshimura et al., 2009). The Fifth Assessment Report (AR5) of the IPCC published in 2014 includes new scenarios based on various technical developments. These new scenarios, called Representative Concentration Pathways (RCPs), are a set of greenhouse gas concentration and emission pathways designed to support research on the impacts of and potential policy responses to climate change (Riahi et al., 2011; Van Vuuren et al., 2011; Moss et al., 2010). The RCPs are also considered to include impacts caused by landuse and land cover (LULC) change.

The present study is conducted to assess the climate change impact on flood hazard potential in Yang River Basin with the following objectives: (i) to develop rainfall-runoff model of the Yang River Basin, (ii) to design synthetic hydrographs with return periods of 25, 50 and 100 years with regard to future climate conditions, and (iii) to simulate flood hazard potential representing return periods of 25, 50 and 100 years under future climate change scenarios. This study assumes that land use activities and population remains the same in future. Although many GCMs are available, only 3 GCMs and two RCPs were selected to construct the future climate scenarios to address the uncertainty in climate change projections.

## 2. Materials and methods

### 2.1. Study area and data description

The Yang River Basin, a sub-basin of Chi River Basin, has a drainage area of approximately 4145 km$^2$ which receives an average annual rainfall of 1390 mm (Fig. 1). The annual relative humidity and temperature are approx. 71% and 26.7 °C respectively in the basin. The basin is influenced by two prominent wind systems, the northeast and southwest monsoons which are responsible for the rainfall patterns and temperature variations. In the northeast monsoons, the dry cold wind picks up some moisture from the northeast, it takes place from mid-October to



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