# THAILAND FLOOD 2011 AND DEVELOPING OF FLOOD PREDICTION TOOL

Supattana Wichakul[1] And Yasuto Tachikawa[2]

[1,2] Hydrology and Water Resources Research Laboratory, Department of Civil and Earth Resources Engineering, Kyoto University, Japan

*E-mail: [1] supattana@hywr.kuciv.kyoto-u.ac.jp, [2] tachikawa@hywr.kuciv.kyoto-u.ac.jp*

The Chao Phraya River basin, the heart of Thailand, is the center of rice production and economic center. Due to the worst flood occurring in the basin on last year, there are many losses in term of human loss, social loss, and economic loss. Therefore, the flood 2011 is not only effected to local people but also all Thai people. This study is to analyses a main result of the flood and to develop a tool (distributed hydrological model) that can reproduce the phenomena of flood in year 2011 based on a concept of infiltration variable capacity and kinematic wave model; and the tool will be used for flood prediction in the future

*Keywords: Thailand Flood 2011, Flood Prediction, Chao Phraya River Basin*

## Introduction

Due to the worst flood occurred in Thailand from July 2011 until the end of year 2011, this study concentrates on studying of the flood and develop the tool for looking forward to the future under the condition of climate change whether the huge flood will occur.

The Chao Phraya River originates in the north region of Thailand and flow direction is from north to south. There are two parts of the Chao Phraya River basin, upper and lower part with an area of 157,925 km$^2$. The upper part of the basin consists of four main sub-basins, Ping River, Wang River, Yom River and Nan River basin. The confluence of Ping and Nan River at Nakorn Sawan province in the central of Thailand is the beginning of the Chao Phraya River. For the purposes of irrigation and power generation, the Bhumibol Dam was built in 1964 on the Ping River with the reservoir capacity of 13.5 MCM, and the Sirikit Dam was built in 1974 on the Nan River with the reservoir capacity of 9.5 MCM.

This study is to analyses a main result of the flood and to develop a distributed hydrological model based on a concept of infiltration variable capacity to reproduce the flood 2011.

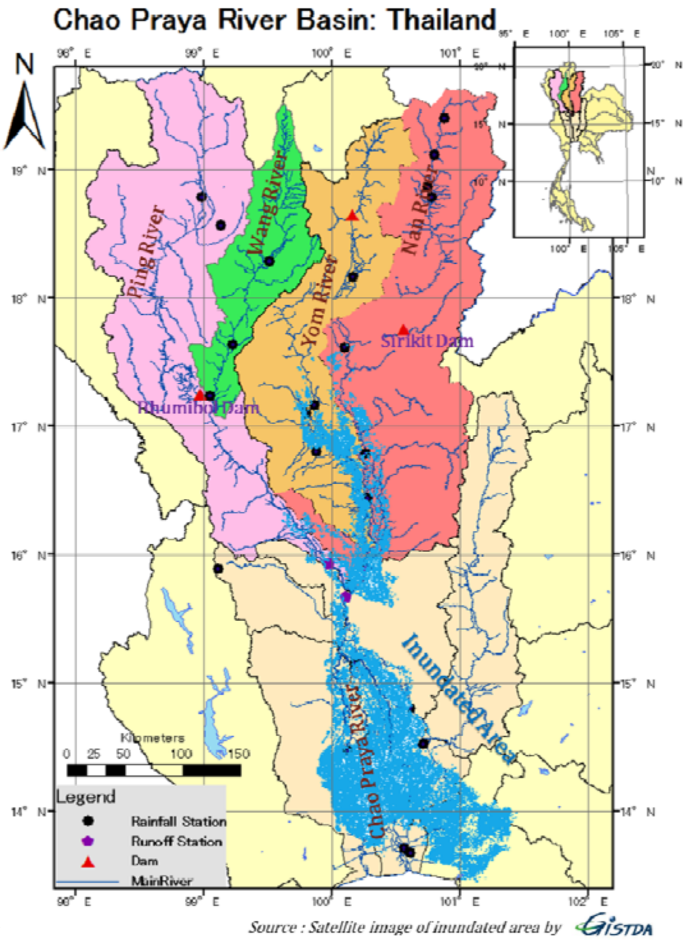


**Figure 1: Diagram of The Chao Phraya River basin of Thailand**

## Methodology

### Rainfall analysis

The rainfall data of 26 stations over the Chao Phraya River basin were obtained for analysing an origin of the amount of the runoff, which is the cause of inundation in the Lower Chao Phraya River basin in 2011. Rainfall data analysis was conducted by considering the accumulated rainfall data of year 2011 with the accumulated average rainfall of year 1980 - 2009 (30 years) and year 2010. The 2-Dimesions rainfall data over the area of latitude 98E-103E and longitude 13N-20N was created to be the input of the hydrologic model.

### Developing of Distributed Hydrological model

From the above process, it can be summarized that whether the flood situation in the lower of Chao Phraya basin mainly depends on a volume of the runoff generated by the precipitation in the upper part of the Chao Phraya basin. The distributed hydrological model consists of a hydrologic model and a flow routing model, which will be explained in more detail as follows.

- Hydrologic Model

A simple water balance model for the catchment, which was developed by Nirupama et al. (1996) using the concept of the Variable Infiltration Capacity (VIC) Model, is utilized in this study. Originally, the VIC model is the simplification of the concept of Xinanjiang (XNJ) Model developed by Zhao et al. (1980). Main feature of the XNJ model is the concept of runoff formation on repletion of storage, which means that runoff is not produced until the soil moisture content of the aeration zone reaches field capacity. The concept of infiltration variable capacity with respect to the soil tension water capacity (STWC) and the portion of pervious and impervious areas are introduced in a particular grid for the surface runoff generation. Quantitatively, the model defines that infiltration capacity as:

$$i = \begin{cases} 0 & if\ 0 \le A \le AI \\ i_m \left[1 - \left(1 - \frac{A - AI}{1 - AI}\right)^{1/b}\right] & if\ AI \le A \le 1 \end{cases} \quad (1)$$

where A = the fraction of the pervious area; AI = the fraction of the impervious area; b = the empirical parameter that represents the shape of the STWC curve, and $i_m$ = maximum infiltration capacity. The runoff will not be produced until soil moisture content of the aeration zone reaches the field capacity which follows the equation (1). And some part of the generated runoff by the STWC will infiltrate the deep aquifer system and go to the sub-surface.

The base flow (sub-surface flow) is estimated by a simple tank model. Hereafter, we would call the model we have developed that “the simplified Xinanjiang Model” (SXNJ Model). The output of the SXNJ model will be runoff at the particular grid with unit of millimetre per hr. This output will be input to the flow routing model.

- Flow Routing Model

Initially, Tachikawa Y. et al (2010) initiated and developed the flow routing model, 1 km distributer flow routiing model (1K-FRM), based on combination of the watershed model and the flow model. The spatial resolution 3 arc-second (about 100 m) of a digital elevation model (DEM) was used in the watershed model. The flow direction was developed follow the 8-direction method. The kinematic wave model was also applied for the watershed model to rout the water through the river according to the flow direction information.

Since, Flow of Chao Phraya River Basin is significantly influenced by the operations of those two main dams in the Ping River basin and Nan River Basin. Consequently, this study also considers and includes the effect of those reservoirs in the 1K-FRM model.

The 1K-FRM, a product of Hydrology and Water Resources Research Laboratory of Kyoto University, can be downloaded through (http://hywr.kuciv.kyoto-u.ac.jp/products/1K-DHM/1K-DHM.html).

**Identification of Model Parameters**

For the model calibration, rainfall data, observed discharge, evapotranspiration, and inflow of the Bhumibol dam and the Sirikit dam were obtained in year 2011. There three monitoring points for comparing the observed discharge with the simulated one are at C.2 station, at upstream of the Bhumibol and Sirikit dams. At this stage the parameter is defined by using the trial-error method and Nash-Sutcliffe efficiency (NSE), Root Mean Square Error (RMSE), and Coefficient of Determination (R2) are used to indicate the model performance.

**Result and discussion**

**Rainfall Analysis**

The results of the rainfall data analysis are shown in Figure 2. The amount of rainfall of year 2011 in the northern sub-basins is significantly higher than those of the averaged 30 years (1980-2009), and year 2010 approximately 36% and 32%, respectively. Whereas, the amount of rainfall of year 2011 in the Lower Chao Phraya River basin is slightly higher than the average 30 years and year 2010 only 2% and 24% by order.

This rainfall data analysis proves that flood 2011 in Thailand is mainly caused by the runoff from the upper part of the Chao Phraya River basin. Therefore, our study area focuses on the runoff occurring in the upper part of the Chao Phraya River Basin, where the outlet is at Nakorn Sawan, C.2 Station. The big amount of rainfall about 1,700-1,900 millimetres was occurred in the Yom and Nana basins.

**Developing of Distributed Hydrological model**

The SXNJ model was simplified to reproduce the flood 2011. The model parameters that is used in the model are as listed in the Table 1. During identifying the model parameters, we found that only a set of parameter could not reproduce the hydrological phenomena of the entire Chao Phraya River basin. Hence, three sets of parameters were in proposed in the model.

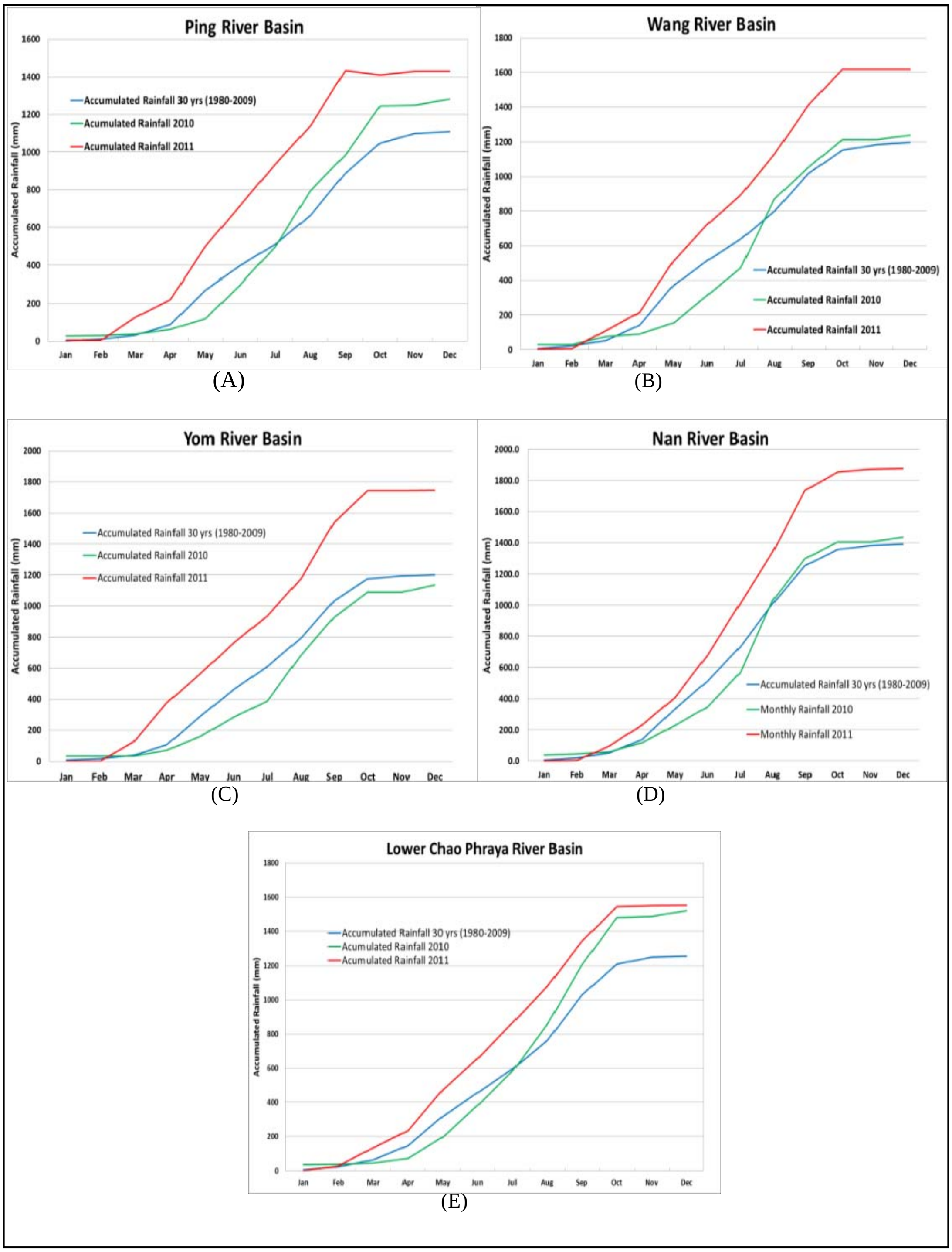


**Figure 2: Accumulated rainfall of the averaged 30 yrs. (1980-2009), 2010 and 2011 in mm. for Ping River Basin (A), Wang River Basin (B), Yom River Basin (C), Nan River Basin (D), Lower Chao Phraya River Basin (E)**

**Table 1: The SXNJ model's parameters**

| Parameter | Definition | Normal grids | Lower Yom+Nan River Basin | Ping+Wang River Basin |
|---|---|---|---|---|
| AI | Fraction of impervious area | 0.35 | 0 | 0.30 |
| $W_m$ | a max. tension water storage (mm) | 350 | 1500 | 400 |
| b | an empirical parameter | 1.5 | 0.2 | 1.5 |
| $k_s$ | a sub-surface coeff. (hr) | 150 | 400 | 200 |
| $k_g$ | a Groundwater coeff. (hr) | 1500 | 40 | 1500 |
| $P_s$ | an empirical sub-surface parameter | 0.6 | 0.6 | 0.5 |
| $p_g$ | an empirical groundwater parameter | 0.6 | 0.6 | 0.6 |

Afterward, 1K-FRM was implemented to rout and generate the river discharge during year 2011 in the Chao Phraya River The overall model performances at the focused points are shown in Table 2. Discharge at C.2 station as shown in the Figure 2. The volume of the simulated hydrograph is 1.55% higher than the observed hydrograph.

**Table 2: The model performance**

| Calibration Period | Statistical criterion | Location | | |
|---|---|---|---|---|
| | | Bhumibol Dam | Sirikit Dam | C.2 |
| **2011** | NSE | 0.62 | 0.71 | 0.87 |
| | RMSE ($m^3/s$) | 310.61 | 265.16 | 498.53 |
| | $R^2$ | 0.63 | 0.75 | 0.87 |

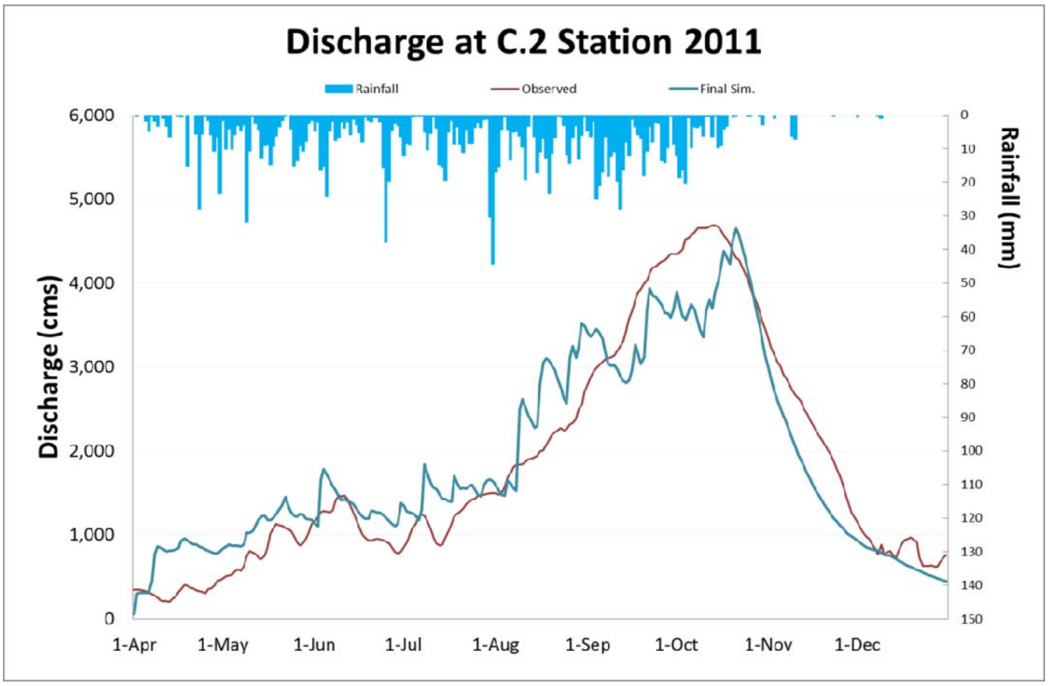


**Figure 2: Comparison of Simulated and Observed Daily Discharge at C.2 Station**

**Conclusion**

One of the important reasons of flooding in the lower Chao Phraya River basin in 2011 is a huge amount of runoff generated by the rainfall occurring in the northern part of the Chao Phraya River basin. At this stage, the tool, a distributed hydrological model, for flood prediction is developed and calibrated, but it is not completely verified and optimized. Finally we expect to acquire the best tool that will be useful for prediction the future flood situation including the impact of climate change in the Chao Phraya River basin of Thailand.

**Acknowledgement**

We greatly thank you to the Royal Irrigation Department of Thailand to provide the relevant data, the rainfall data and Observed discharge.

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