# Flood Inundation Analysis by Using RRI Model For Chindwin River Basin, Myanmar

**Aye Aye Naing**
**MEE14625**

**Supervisor : Dr. Miho Ohara**
**Dr. Duminda Perera**
**Dr. Yoshihiro Shibuo**

**ABSTRACT**

Floods occur during the south west monsoon between the months of June to October in Myanmar on an almost annual basis. In order to reduce flood damage, it is essential to identify flood prone area and prepare flood inundation scenarios by developing flood hazard maps. In Chindwin River Basin (CRB) in Myanmar, DMH (Department of Meteorology and Hydrology) has developed flood hazard maps by using HEC-RAS model. This study aimed to conduct flood inundation analysis by using Rainfall Runoff Inundation Model (RRI-Model) and develop flood hazard maps with different return periods. As a result of comparing flood hazard maps by RRI model and HEC-RAS model, it was found that both models identified similar high risk area. However, flood inundation depth by RRI model was slightly higher than that by HEC-RAS model.

## INTRODUCTION

The Chindwin river basin (CRB) is the third largest river in the North Western part of Myanmar. The CRB has the catchment area of 110,350 $km^2$ and 901 km long from north to south. The source of Chindwin radiates from the Kachin plateau. The basin is important for agriculture production and food exportation for the country and farmers cultivate the paddy and crop plants in the flood prone area of the basin. CRB is selected as the pilot area because it represents typical basins and flood plains that are prone to annual monsoon floods in Myanmar. Location of Chindwin river catchment area was shown in Figure 1.

Major Township in CRB is Homalin. Elevation in the study area ranges from 50 m to 1692 m above mean sea level. Most of the buildings in Homalin locate in flood zones of river. The population of Homalin Township is approximately 258,206 people and the western and north western part of the study area have the mountain area. In Homalin, 9916 households, 9950 families and 59594 populations were affected by 1997 July flood. 3867 households, 3867 families and 28399 populations were affected by 1997 September flood.

Department of Meteorology and Hydrology (DMH) conducted mini project for flood hazard mapping in Homalin Township in Chindwin River Basin in 2012-2013.

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*Senior Observer, Department of Meteorology and Hydrology, Myanmar

**International Center for Water Hazard and Risk Management (ICHARM), PWRI

It simulated flood inundation for different return periods such as 10, 50, 100, 500 years by HEC-RAS model using the annual peak discharge from 1968 to 2011 at Hkamti and Homalin stations which are upstream and downstream stations of DMH.

The main objective of this study is to conduct flood inundation analysis by using RRI model for CRB. Inundated areas are estimated by RRI simulations using MODIS satellite images and flood hazard maps are developed in Homalin Township for different return periods. Finally, flood hazard maps by RRI model and HEC-RAS model are compared and discussed.

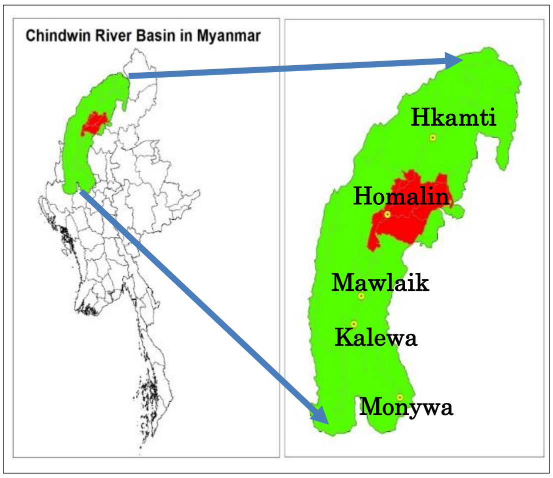


**Figure: 1 Location of Chindwin Catchment Area & Homalin Township**

## DATA AND METHODOLOGY

At first, RRI model is applied to CRB and the floods in 1997 and 2004 were simulated. The topography data such as digital elevation model, flow direction and flow accumulation and observed rainfall data is used as input data for the model. The model can produce inundation map with depth and duration and calculated discharge. The model is calibrated with observed discharge.

Then, inundation area by RRI model is validated based on inundation area at part of flood events. These maps are derived using Moderate Imaging Spectroradiometer (MODIS).

Next, frequency analysis is conducted using observed rainfall data from 1992 to 2013.The design rainfalls for 10, 25, 50, 100 years are estimated by using GEV and Gumbel distribution.

Finally, inundation maps are developed by simulation model and compared with the maps by HEC-RAS model by DMH.

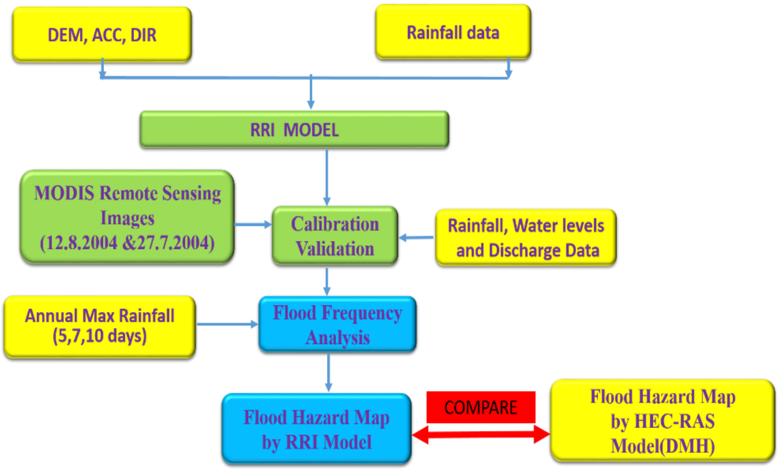


**Figure: 2 Schematic Diagram of Study approach**

## RESULTS AND DISCUSSION

### Flood Inundation Analysis by RRI model

Flood inundation simulation was conducted by using RRI Model with six months rainfall data in 1997 and 2004. At first, the data of five rain gauge stations were arranged in text file. Then Rain Thiessen program in the RRI Model was used to create a rainfall file to use in the model. At Homalin station, simulation result was higher than observed discharge and reached at peak level in July second week in 1997. On the other hand, observed discharge was higher than simulation result in July third week in 2004. Hydrographs for 1997 and 2004 flood event at Homalin station were shown in Figures 3.

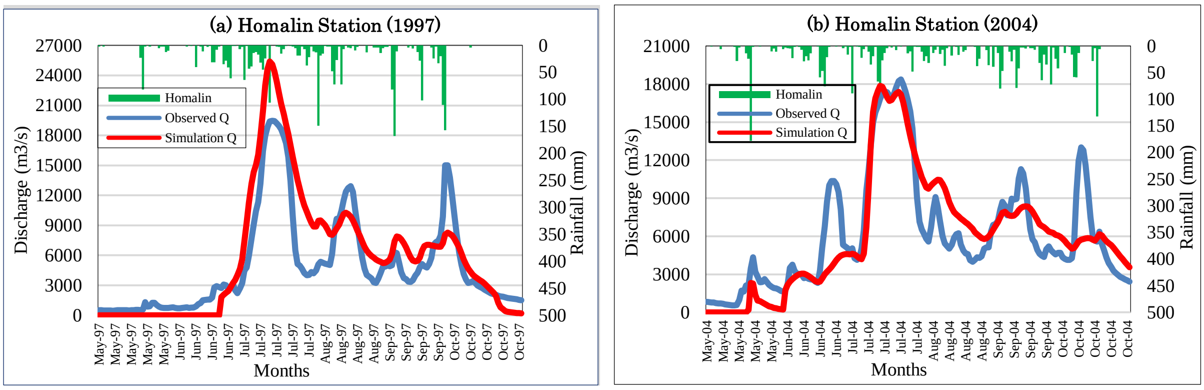


**Figure: 3 Simulation & Observed Discharge at Homalin Station from May to Oct, (a) 1997 & (b) 2004 (With Infiltration)**

### Validation of Homalin area for RRI Model and MODIS Satellite Images

Two MODIS images of 27.7.2004 and 12.8.2004 were used for testing the best suited index for Homalin area. Identification of water pixels was done using the following threshold values, NDVI>=0.2, LSWI>=0.2 and MLSWI>=0.7. In this study, MLSWI threshold value was the most effective at 0.7 to identify water bodies such as muddy water and mixed water caused by flood.

Figure 4 shows that the flood maps computed using for RRI model and MODIS (MLSWI) at Homalin station. The CSI value was obtained to be 0.27 for 27.7.2004. The CSI value was obtained to be 0.16 for 12.8.2004. In the case of 27.7.2004, 27% of the inundation area by RRI model were also identified by MODIS derived flood maps.

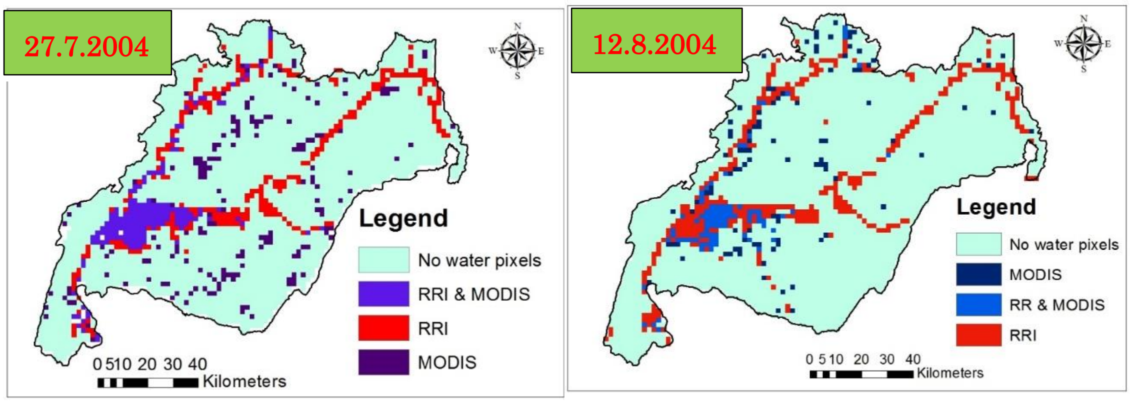


**Figure: 4 Flood Maps computed using for RRI Model & MODIS (MLSWI) at Homalin Station**

**Frequency Analysis Results**

The frequency analysis was conducted by using the average maximum rainfall of 5 days, 7 days and 10 days. Both Gumbel and GEV was suitable but GEV was much better than Gumbel as shown in Figure 5. From the result of Chi Square Test between observed and expected value, GEV was selected as it has smaller value of 2.959. 10-days maximum rainfall value based on GEV was obtained to be 606.64 mm for 100 years return period. The ratio of 10-days maximum rainfall for 100 years return period to the rainfall of 2004 flood event was calculated to be 1.163 times. Design rainfall for 100 Period was obtained by magnifying the peak rainfall values between 9.7.2004 to 17.7.2004 by using this ratio.

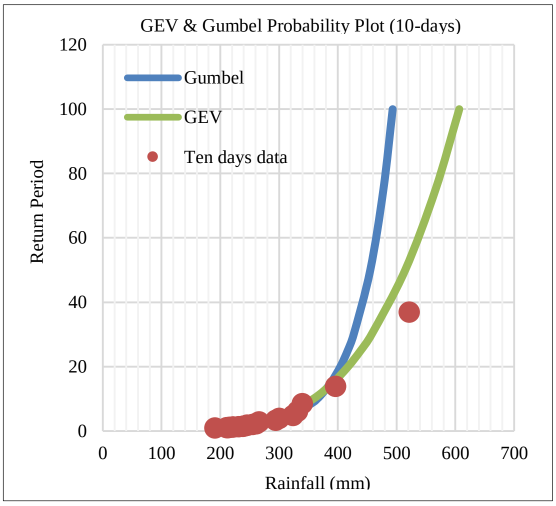


**Figure: 5 Probability Plot of 10 days Maximum Rainfall**

**Comparison of the Simulation Discharge for 100 year return period by RRI & HEC-RAS model**

One of the major purpose of this study is to develop the flood hazard map for flood management by RRI model simulation. Flood inundation maps of 10, 50 and 100 years return periods were shown in Figure 6.

In order to check the meaning of 100 years return period, both simulation and discharge in this study and DMH study were compared. Simulation results by RRI model and HEC-RAS model by DMH identified similar discharge values for 100 years return period. Simulation discharge values by RRI model (21668 $m^3/s$) was less than HEC-RAS model (21836 $m^3/s$). Two maps by RRI and HEC-RAS Model for 100 years return period in Homalin Township were compared in Figure 6.

Flood area for different return periods for RRI and HEC-RAS model was shown in Figure 7. The results showed the flood depth is 0 to more than 5 m. The flood inundated area at Homalin Township by RRI model was obtained to be 450 $km^2$, 462 $km^2$ and 493 $km^2$ for 10, 50 and 100 years return periods. These values was more than the flood inundated area by HEC-RAS model (DMH) which was obtained to be 377 $km^2$, 411 $km^2$ and 424 $km^2$ for 10, 50 and 100 years return periods. Simulations by RRI model and HEC-RAS model by DMH identified similar inundation area, although inundation depth by RRI model was higher than HEC-RAS model.

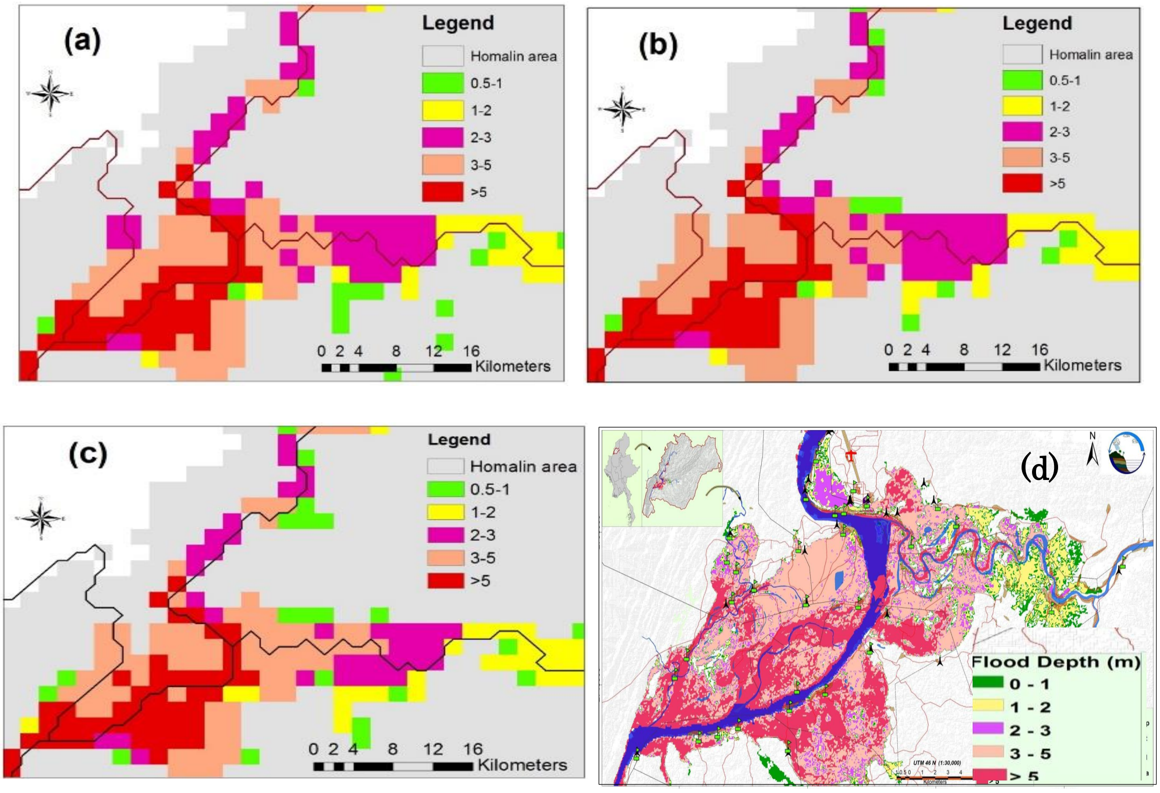


**Figure: 6 Comparison of Flood Hazard Maps for Different Return Period:**

**(a) 10-year return period by RRI; (b) 50-years return period by RRI, (c) 100-years return period by RRI, (d) 100-years return period by HEC-RAS Model**

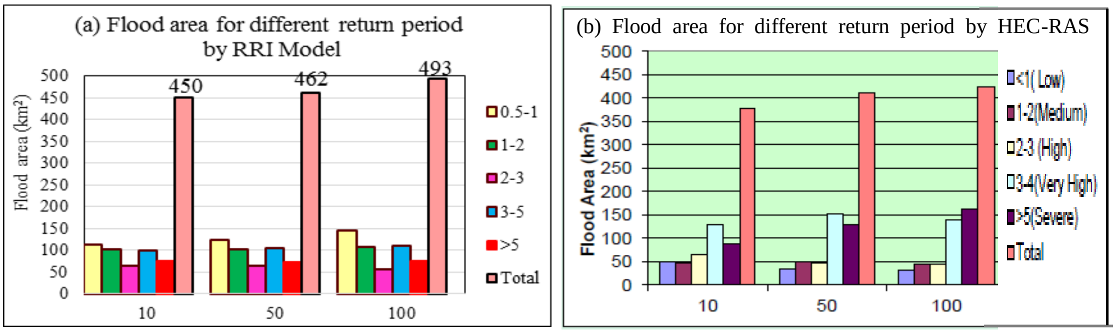


**Figure: 7 Flood Area for Different Return Periods: (a) RRI model; (b) HEC-RAS (DMH)**

## RECOMMENDATION

This study aimed conducted flood inundation analysis by using Rainfall-Runoff-Inundation Model (RRI Model) in CRB. Floods hazard maps for different return periods such as 10, 50 and 100 years were developed based on frequency in Homalin Township. Finally, these maps were compared with the maps obtained by DMH by using HEC-RAS model. As a result of comparing flood hazard maps by two models, it was found that both models identified similar high risk area. However, flood inundation depth by RRI model was slightly higher than that by HEC-RAS model.

This study revealed that RRI model is also useful for flood inundation analysis in CRB. Especially, RRI model could be useful tool because this is two dimensional simulation model considering the effect of soil type and land use although HEC-RAS Model used by DMH study is one dimensional model which does not include these effect.

As further study, discussion about flood events with local people and surveying in flood affected area are very important to enhance the accuracy of the simulation. These observations should be conducted for future research. In addition, to improve flood inundation analysis and flood inundation mapping, the observed rainfall data is not enough and more meteorological stations should be necessary for more accurate simulation for CRB.

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