DEVELOPMENT OF FLOOD INUNDATION MAP FOR BAGO RIVER BASIN USING DIFFERENT MODELS

Presented by

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Professor

YTU

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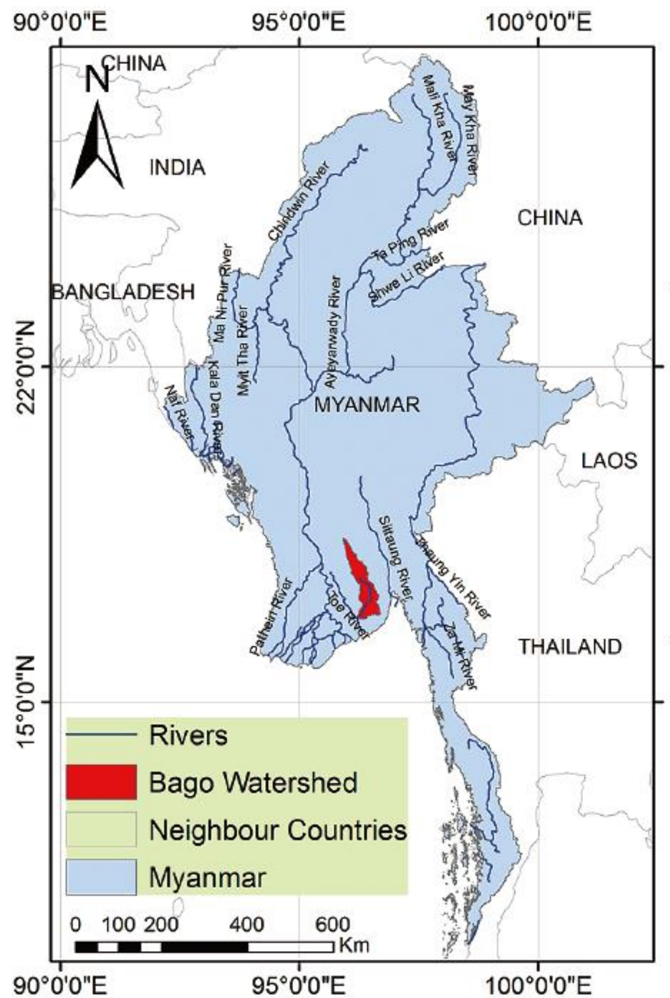
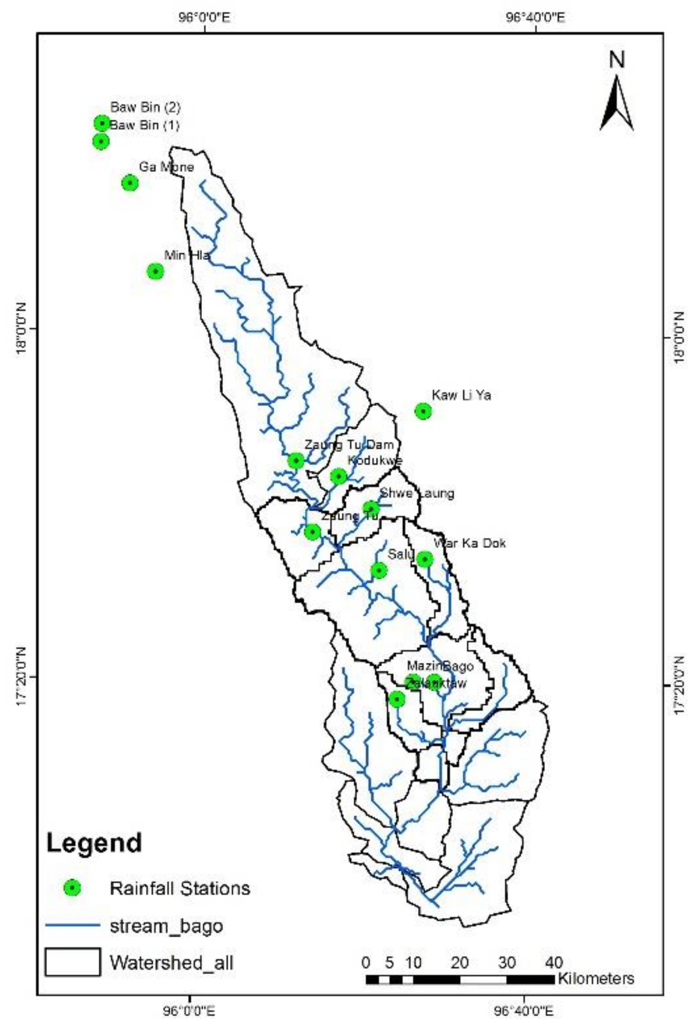
INTRODUCTION

- Flood inundation modeling involves hydrologic modeling to estimate peak flows from storm events, hydraulic modeling to estimate water surface elevations, and terrain analysis to estimate the inundation area
- One of the methods to prevent and reduce losses is to provide reliable information to the public about flood risk through a flood inundation map

Study Area


90°0'0"E
95°0'0"E
100°0'0"E
CHINA
INDIA
BANGLADESH
MYANMAR
LAOS
THAILAND
22°0'0"N
15°0'0"N
N
Rivers
Bago Watershed
Neighbour Countries
Myanmar
0 100 200 400 600 Km

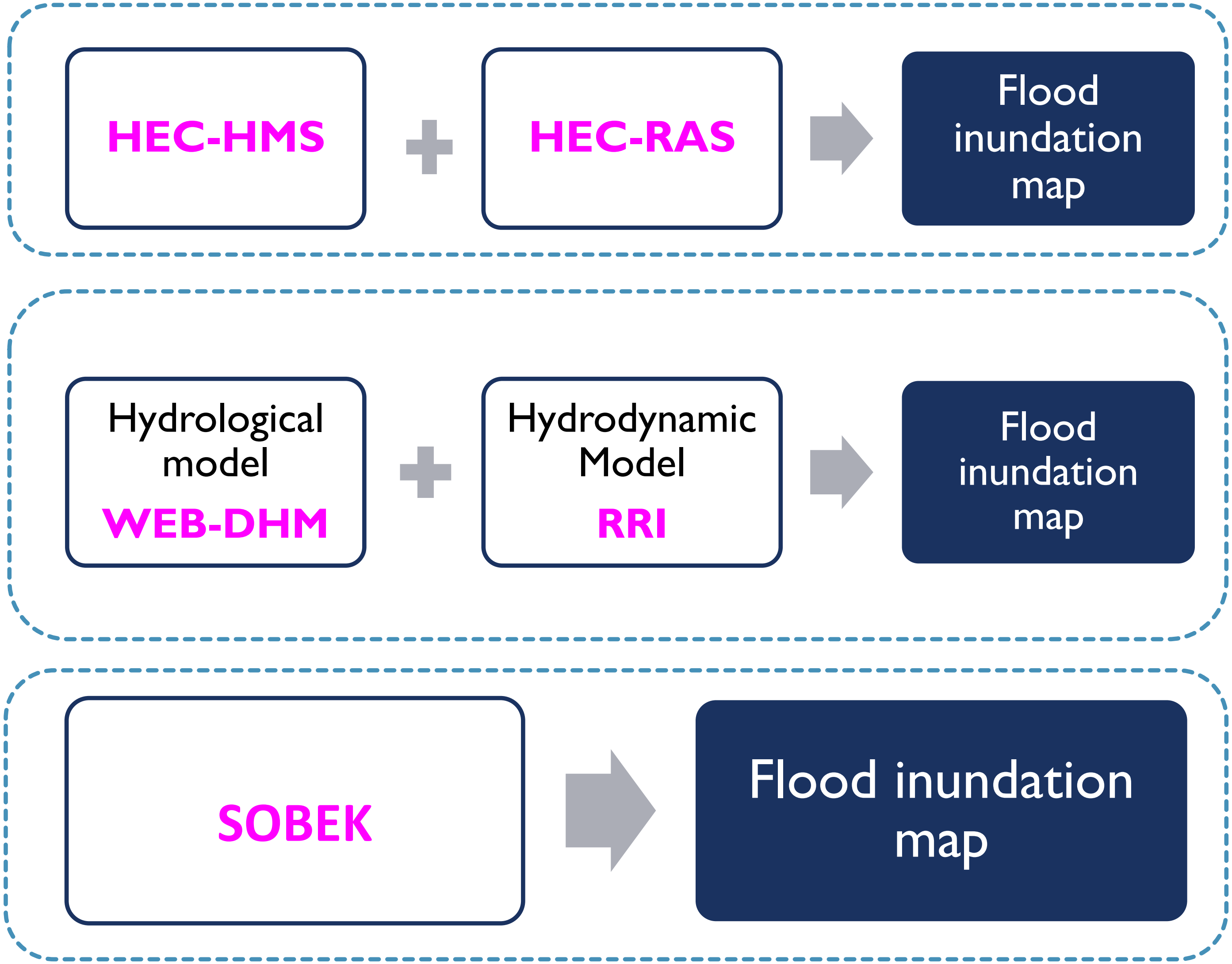

96°0'0"E
96°40'0"E
18°0'0"N
17°20'0"N
N
Baw Bin (2)
Baw Bin (1)
Ga Mone
Min Hla
Kaw Li Ya
Zaung Tu Dam
Kodukwe
Shwe Laung
Zaung Tu
War Ka Dok
Salu
Mazin
Bago
Zalanktaw
Legend
Rainfall Stations
stream_bago
Watershed_all
0 5 10 20 30 40 Kilometers

COUPLING HYDROLOGICAL AND HYDRAULIC MODELS

- Flow calculated by the hydrological model is used as input at the upstream boundary condition of the hydraulic model. The output of the hydrologic model, the flood hydrographs, were used as input in the hydraulic model for calibrating and validating with the known water levels.

- Floodinundation mapping is a sequential process, starting with a hydrological analysis, followed by a hydraulic analysis and geospatial processing with spatial analysis tools such as geographic information system (GIS) and remote sensing.

MODEL USED



HEC-HMS
HEC-RAS
Flood inundation map
Hydrological model
WEB-DHM
Hydrodynamic Model
RRI
Flood inundation map
SOBEK
Flood inundation map

No.	Sources	Collected Data	Remarks
1	Department of Meteorology and Hydrology (DMH)	Daily precipitation data, Daily water level data, Daily discharge data	1987-2017
2	Irrigation and Water Utilization Management Department (IWUMD)	Daily precipitation data, Daily dam inflow / outflow data	2011-2017
3	Department of Hydropower Implementation (DHPI)	Daily precipitation data, Daily dam inflow / outflow data	2011-2017
4	SATREPS project	128 Cross Sections (Bago River) 20 Cross Sections (Bago-Sittaung Canal)	2013~2015 2018
5	Seemanta sharma Bhagabati ,2018	Digital Elevation Model (DEM)	10 m resolution
6	(http://www.hydrosheds.org/page/availability)	HydroSHEDS DEM	3-sec resolution
7	(http://www.esa.int/due/ionia/globcover)	Global Land Cover map	2009
8	(https://rlcms-servir.adpc.net/en/landcover/#)	Regional Land Cover map by SEVIR MEKONG	2016
9	DSMW (www.fao.org)	Soil maps	2003
10	Sentinel ESA Copernicus (https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar)	Sentinel 1 SAR image	2015-2017
11	UNOSAT (https://unosatgis.cern.ch/arcgis/rest/services/FP02/FP02_FL_20150703_MMR_20150809_Flood_Radarsat2/MapServer?f=lyr)	Radarsat 2 flood water extent analysis map for 9 August 2015	2015
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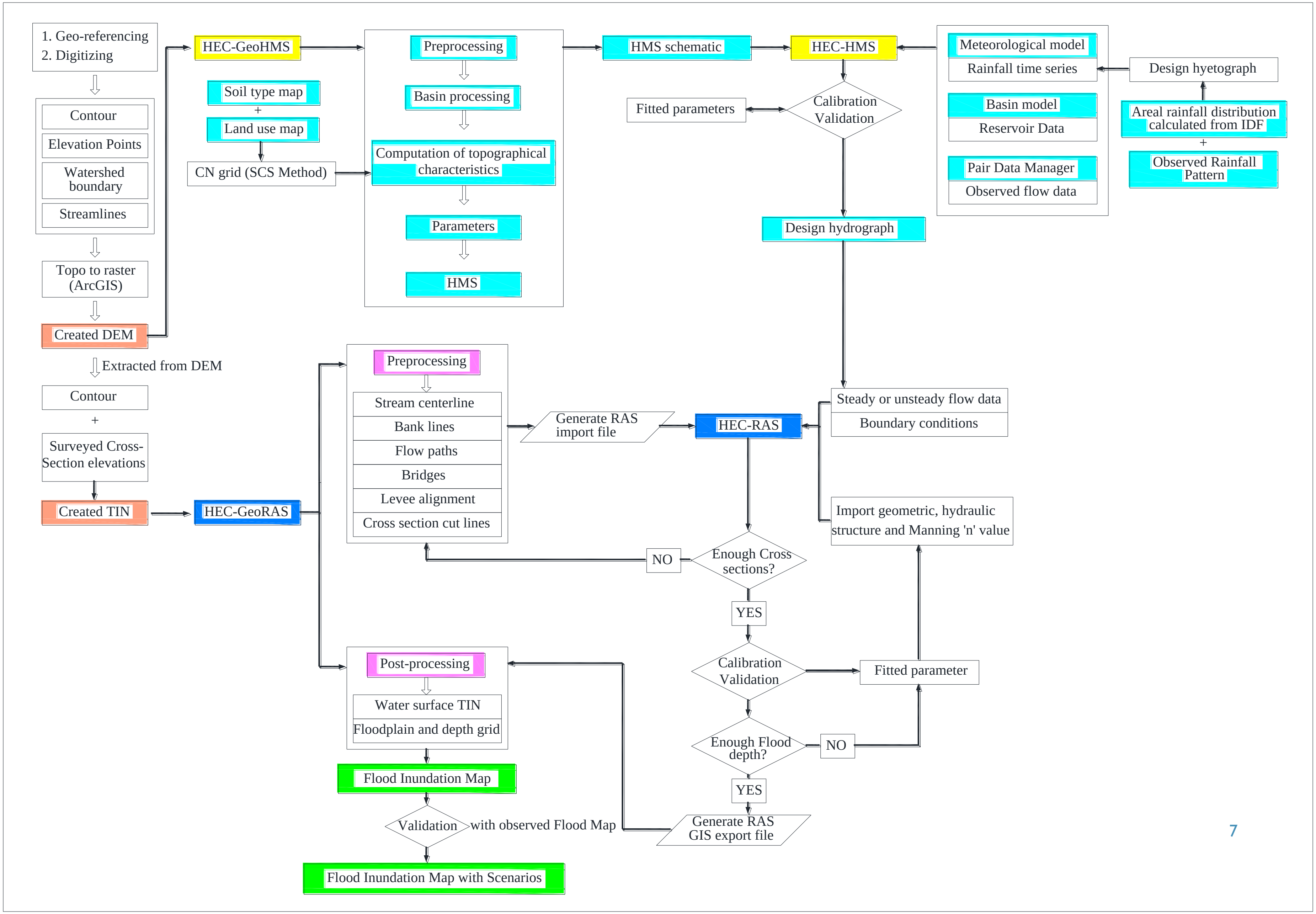

1. Geo-referencing
2. Digitizing
Contour
Elevation Points
Watershed boundary
Streamlines
Topo to raster (ArcGIS)
Created DEM
Extracted from DEM
Contour
+
Surveyed Cross-Section elevations
Created TIN
HEC-GeoHMS
Soil type map
+
Land use map
CN grid (SCS Method)
Preprocessing
Basin processing
Computation of topographical characteristics
Parameters
HMS
HMS schematic
HEC-HMS
Fitted parameters
Calibration
Validation
Design hydrograph
Meteorological model
Rainfall time series
Basin model
Reservoir Data
Pair Data Manager
Observed flow data
Design hyetograph
Areal rainfall distribution calculated from IDF
+
Observed Rainfall Pattern
HEC-GeoRAS
Preprocessing
Stream centerline
Bank lines
Flow paths
Bridges
Levee alignment
Cross section cut lines
Generate RAS import file
HEC-RAS
Steady or unsteady flow data
Boundary conditions
Import geometric, hydraulic structure and Manning 'n' value
NO
Enough Cross sections?
YES
Calibration
Validation
Fitted parameter
Enough Flood depth?
NO
YES
Generate RAS GIS export file
Post-processing
Water surface TIN
Floodplain and depth grid
Flood Inundation Map
Validation
with observed Flood Map
Flood Inundation Map with Scenarios

HEC-HMS MODEL COMPONENTS

Precipitation

- User-specified hyetograph
- User Gage Weighting
- Inverse-Distance Gage
- Frequency storm
- SCS hypothetical storm
- Standard project storm

Surface Runoff (Transform)

- Clark's UH
- Snyder UH
- SCS UH
- ModClark
- Kinematic wave
- User-specified UH
- User –specified S-graph

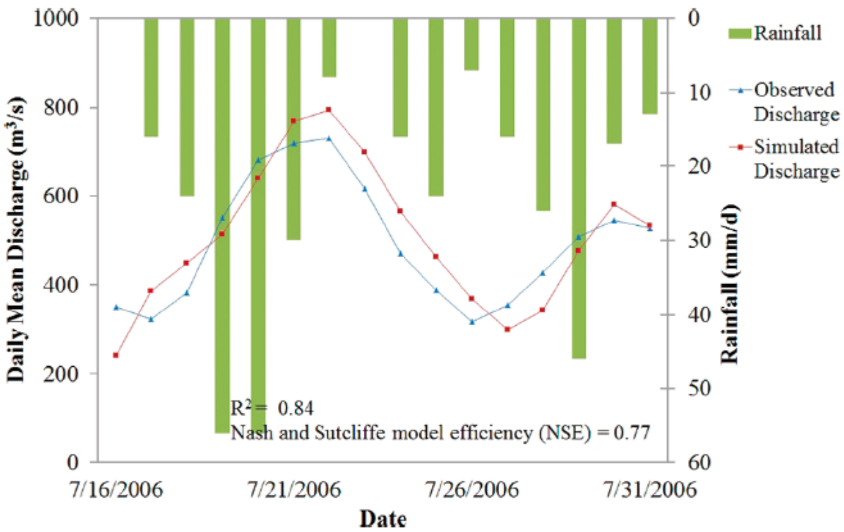
Infiltration

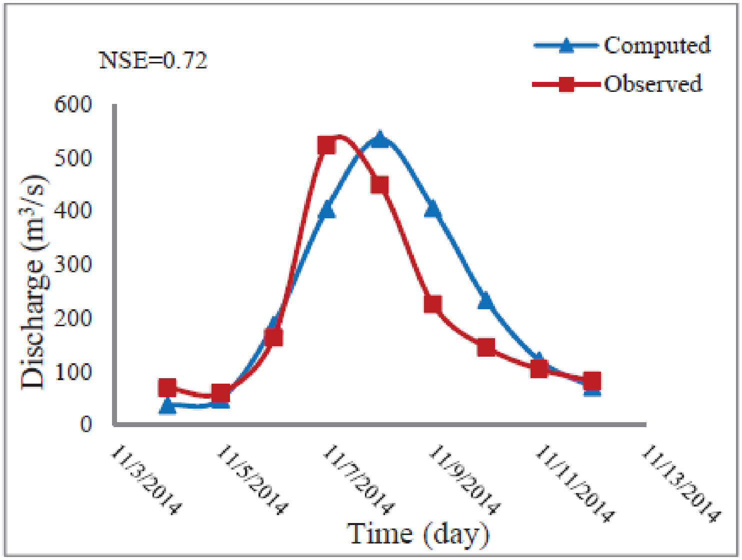
- SCS curve number
- Initial and Constant
- Deficit and Constant
- Gridded SCS curve number
- Green and Ampt
- Soil Moisture Accounting
- Gridded Soil Moisture Acc

Channel flow routing

- Kinematic wave
- Lag
- Modified Puls
- Muskingum
- Muskingum-Cunge
- Standard Section
- Muskingum-Cunge-8-point Section
- Confluence
- Bifurcation

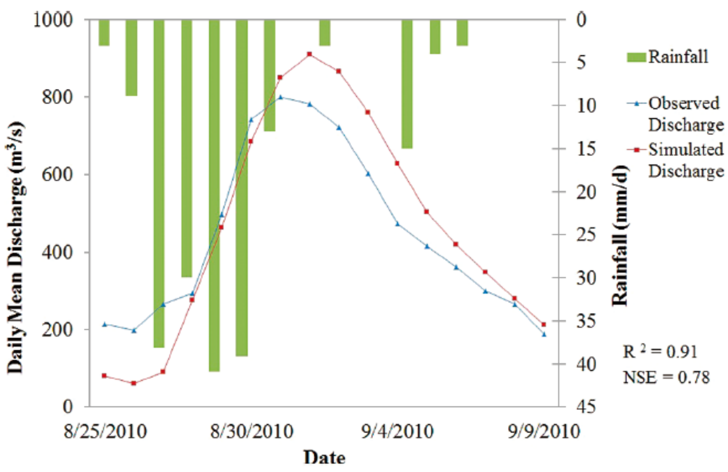
HEC-HMS
Calibration Results

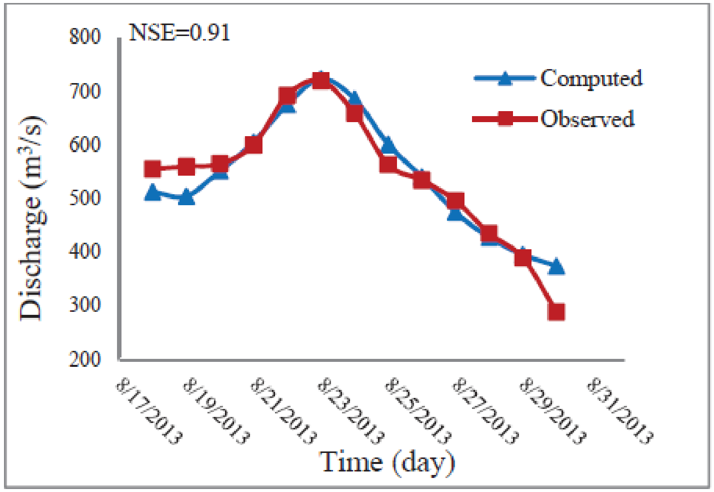




HEC-HMS

Validation Results

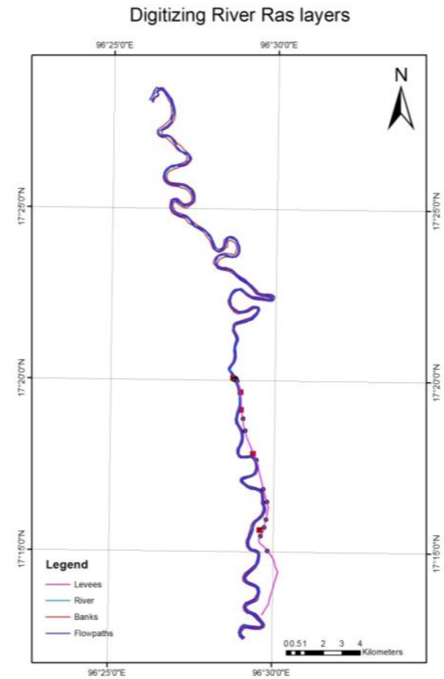


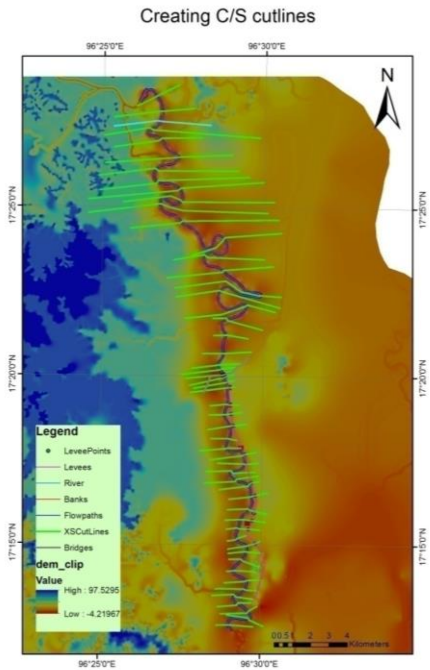


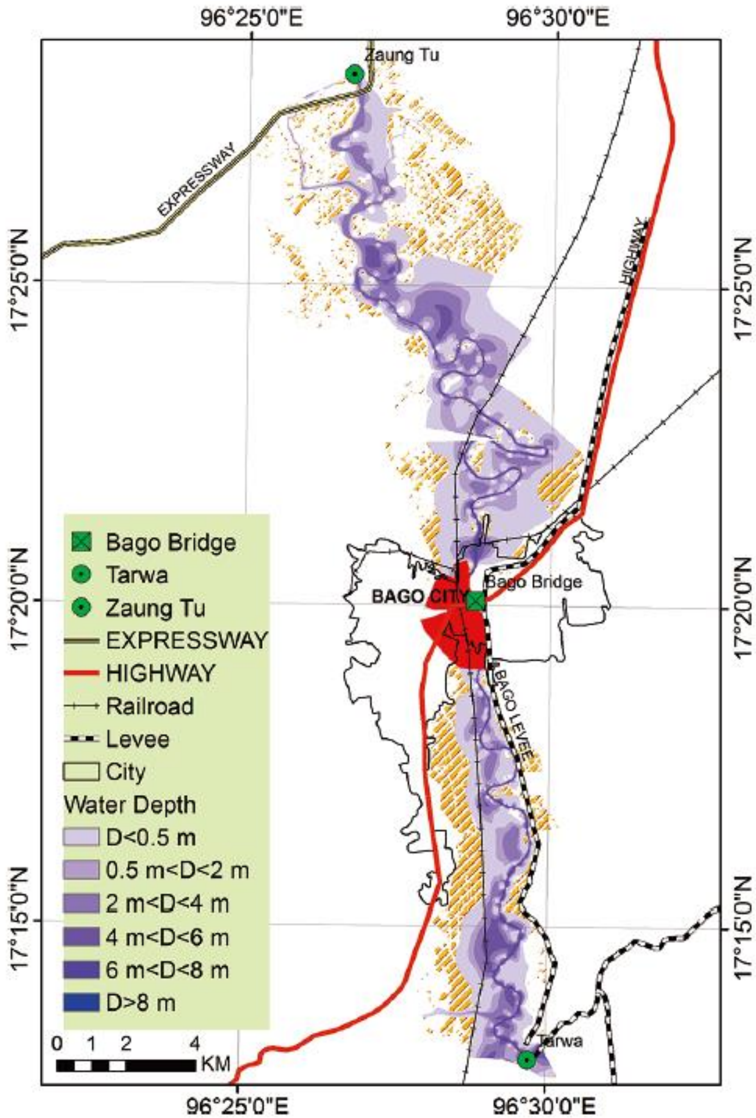
HEC-RAS MODEL

- Flood routing along the river network was simulated with HEC-RAS

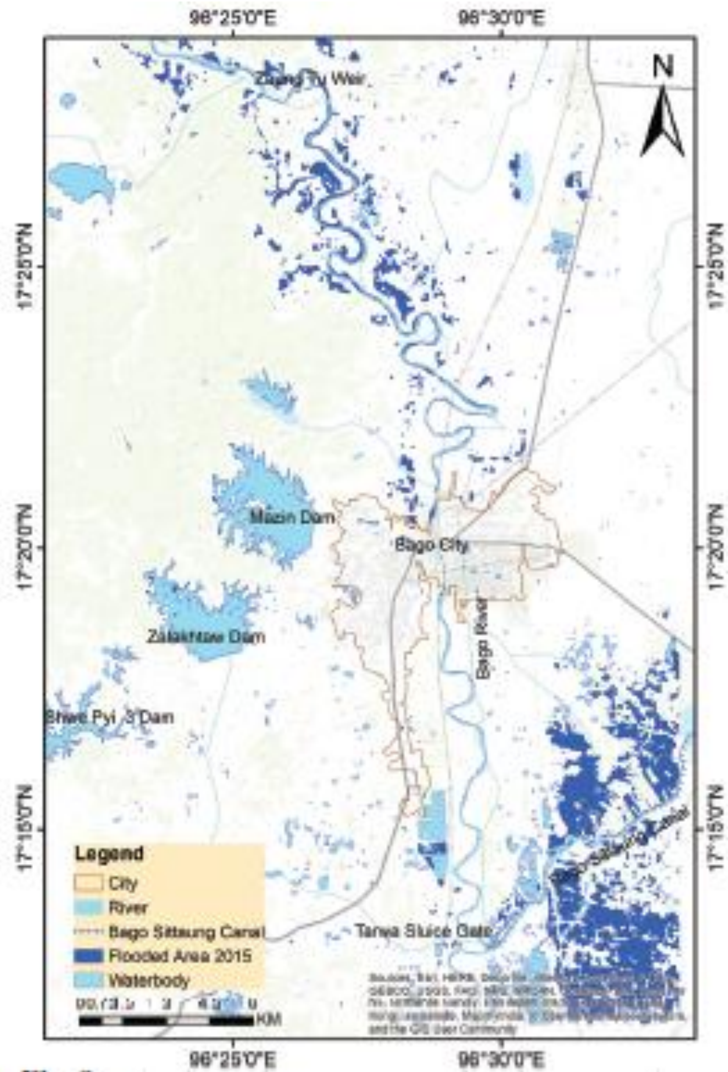
- Conducted 50 km reach starting from Zaungtu weir to Tarwa outlet



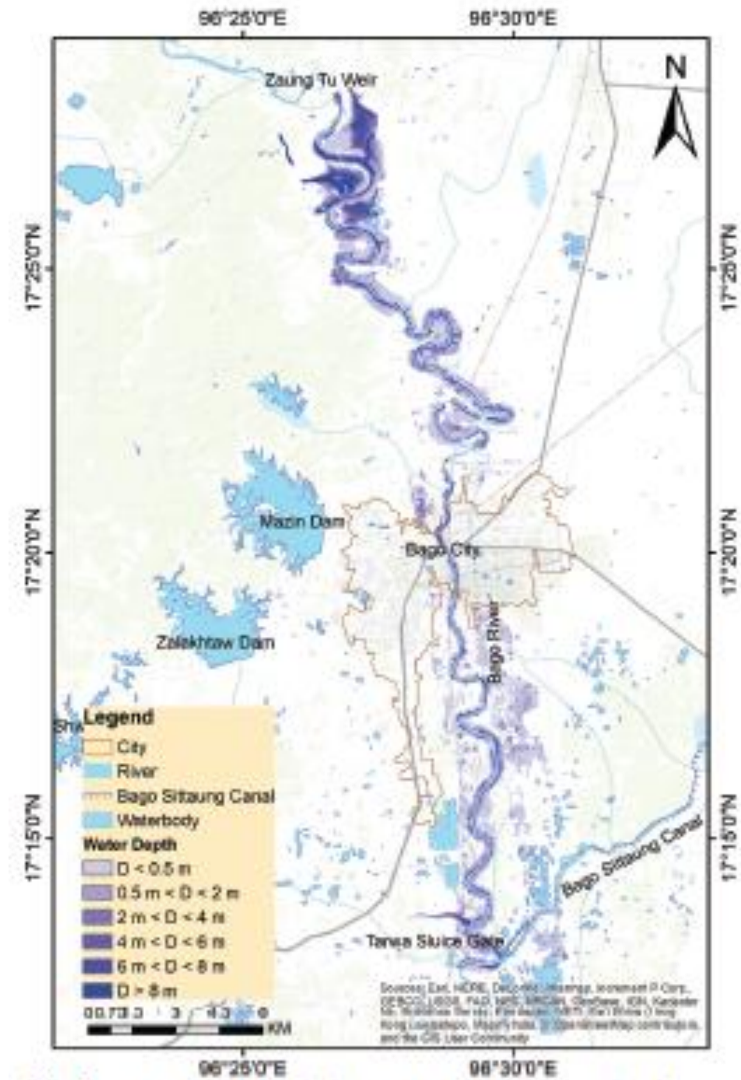




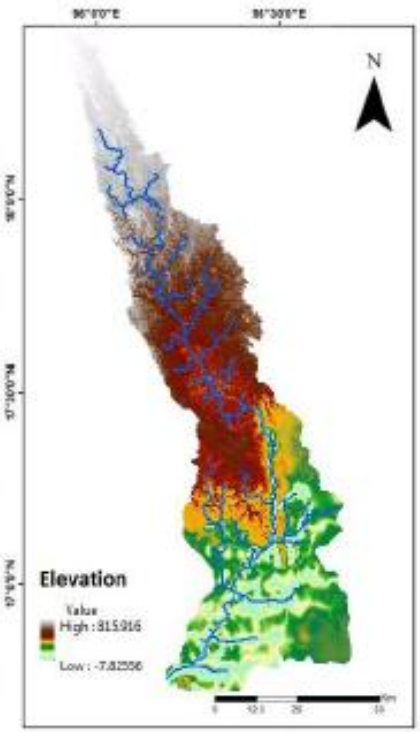
Comparison of 2006 July flood inundation map with ALSOS PALSAR image



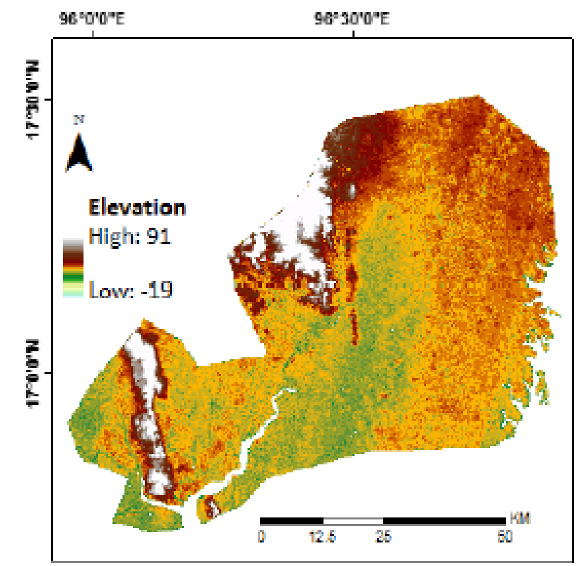
Flood inundation extent predicted from 2015, August Sentinel-1 SAR image.



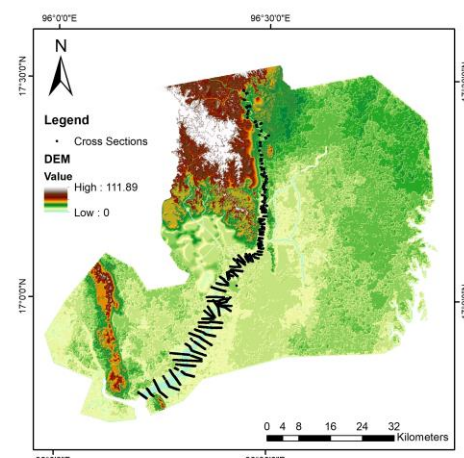
Simulated flooded area for 2015 August flood using HEC-RAS.



(Source:Khaing,2012)

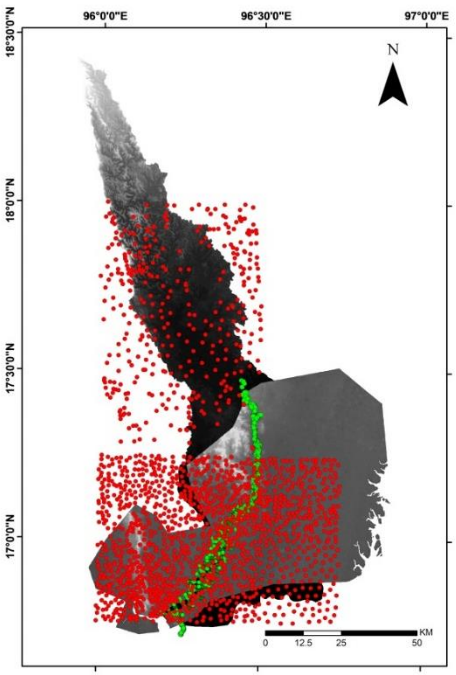


ALOS DSM developed by UTokyo

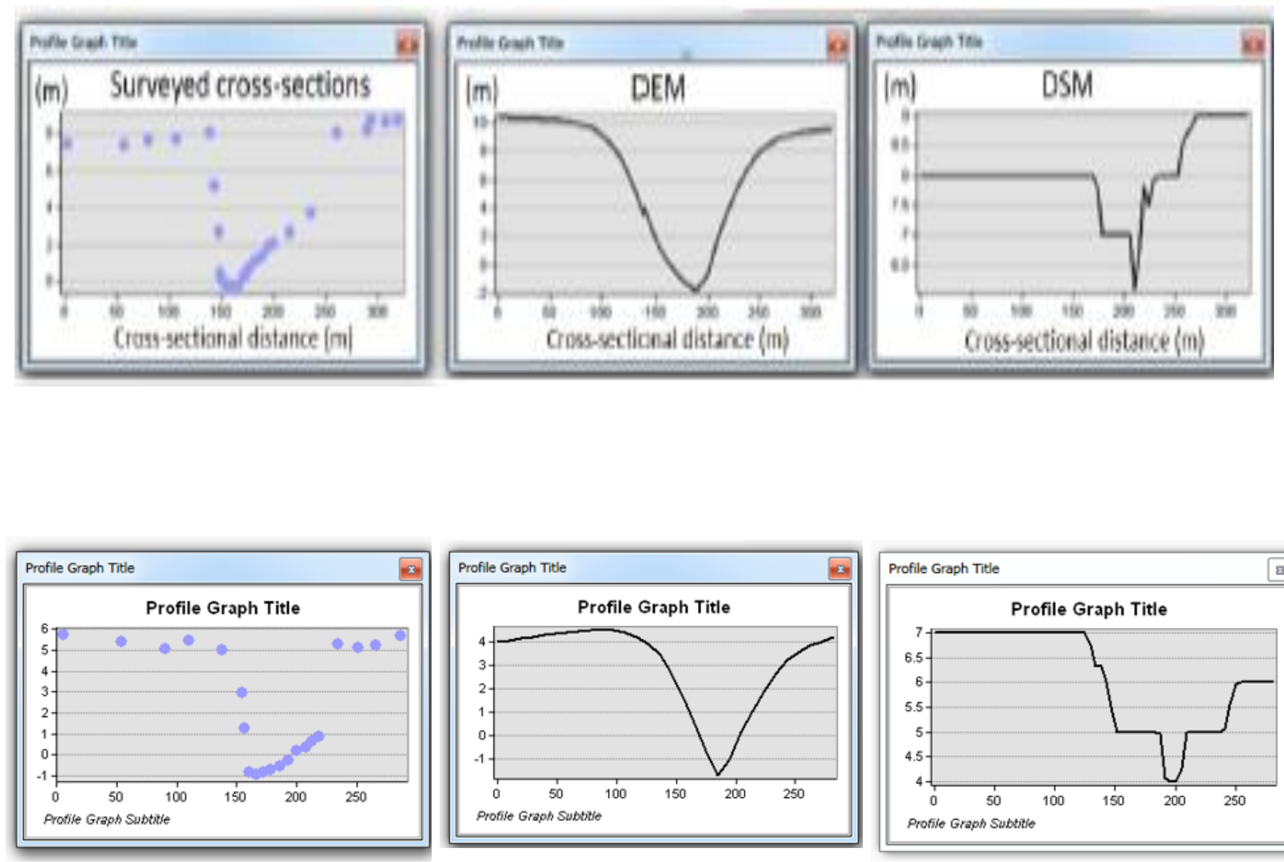


Enhanced DEM

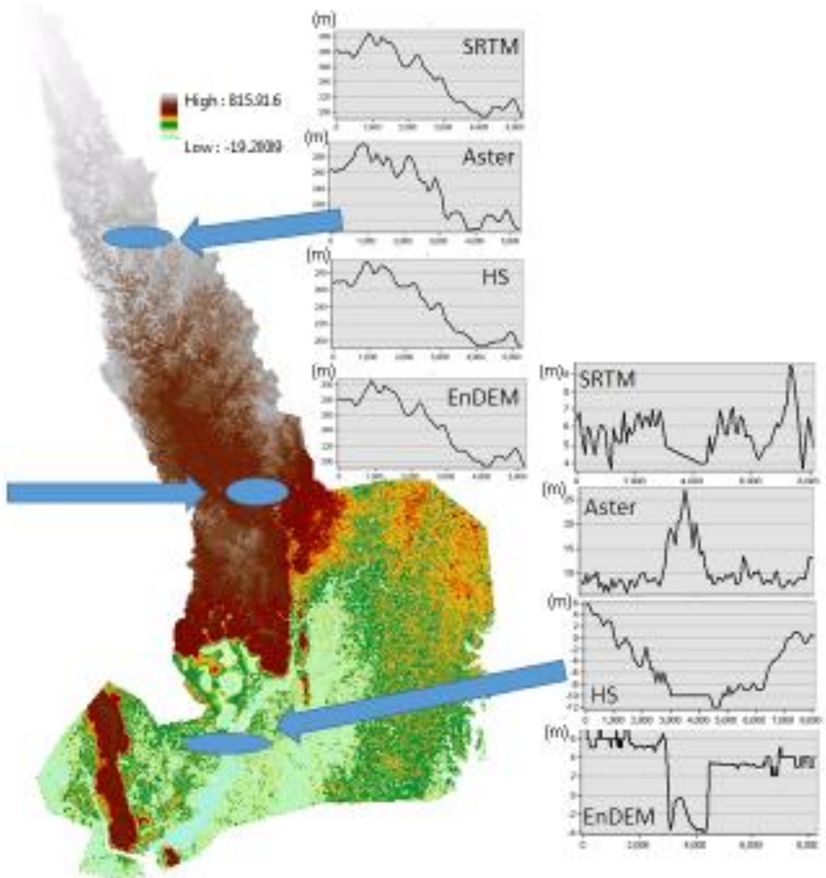
(Source: Seemanta,2018)



Digitization of High Points



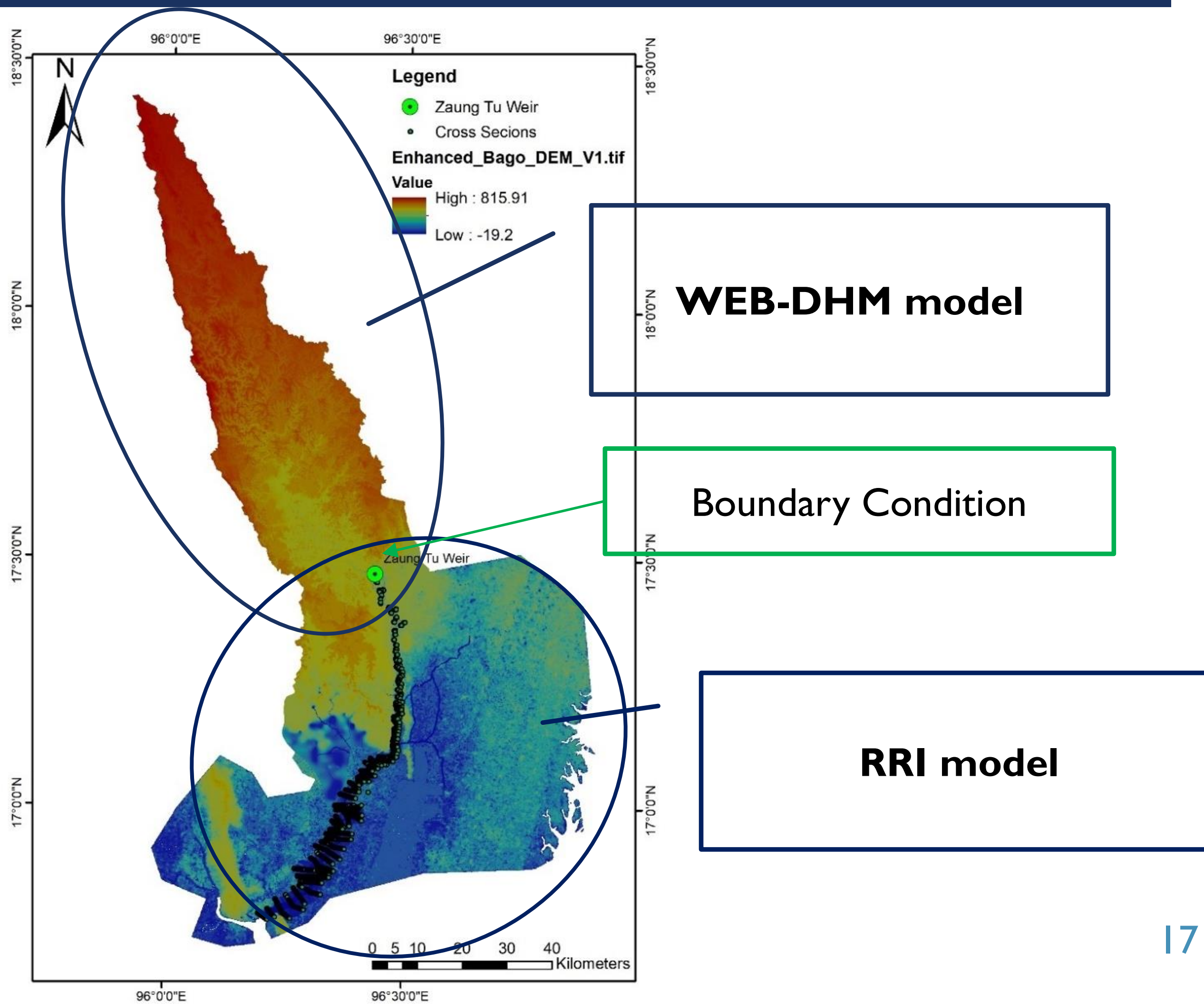
Comparison of cross-section and the DEM & DSM



Comparisons of vertical profile for 4 DEMs at top and lower basin.

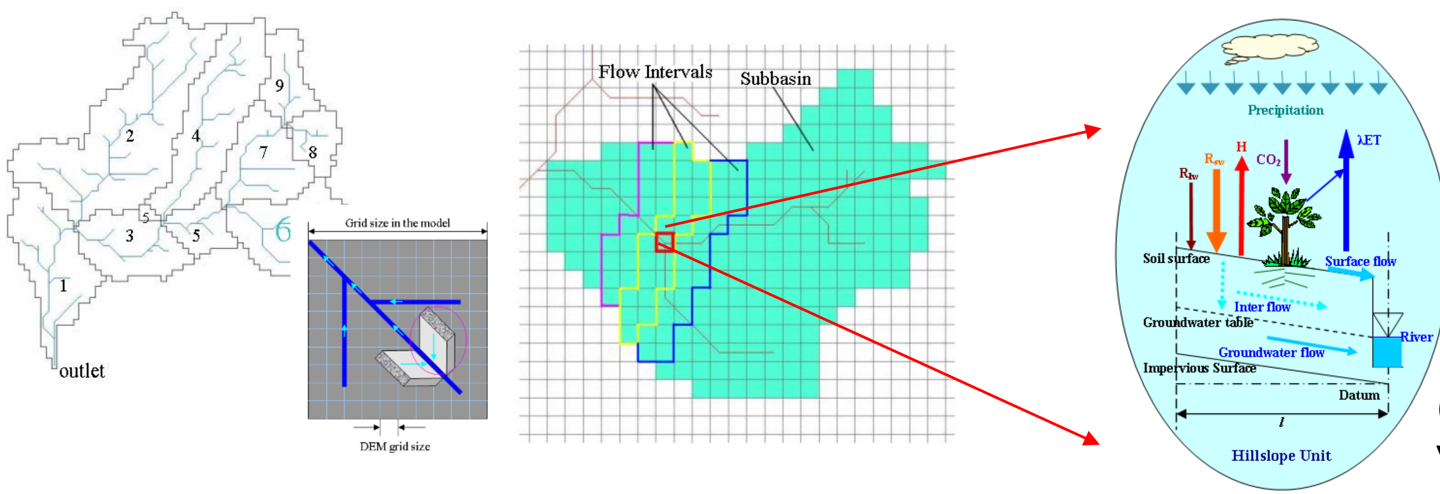
(Source: Seemanta,2018)

WEB-DHM MODEL COUPLED WITH RRI MODEL



WATER AND ENERGY BUDGET BASED DISTRIBUTED HYDROLOGICAL MODEL (WEB-DHM)

- **Spatially-distributed** biosphere hydrological model – included water and energy balance as well as CO_2 flux
- More reliable estimation of **Evapotranspiration**
- Coupled with GCM and forecasting data for flood and drought
- Applicability with **large** river basins
- Satellite data can be used for land use, soil, vegetation, etc…



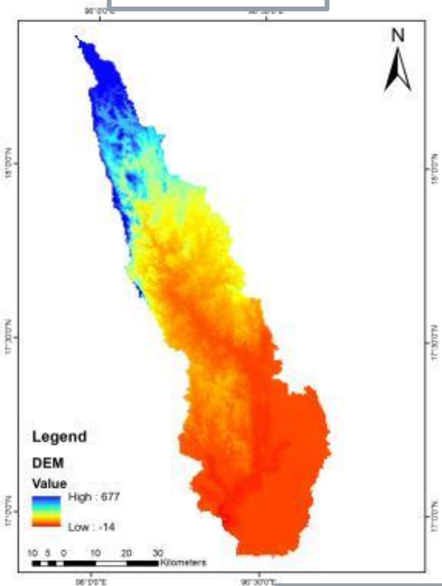
(Source: Wang,2009)

Parameters used for setting up the WEB-DHM

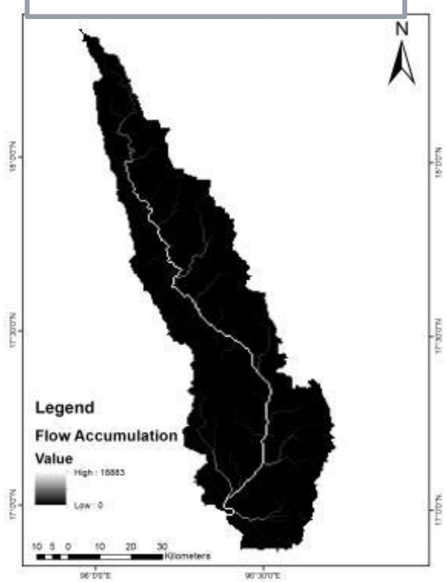
Parameter	Data source	Global/local dataset
Elevation	HydroSHEDS (http://hydrosheds.cr.usgs.gov/index.php)	Global
Land Use	USGS Land Use (SiB2)	Global
Soil	FAO soil	Global
LAI/FPAR	MODIS	Global
Meteorological parameters (T, P, U,V, LW, SW)* *Temperature, Pressure, Wind, Long Wave and Short wave radiation	JRA-55 (Japan Reanalysis data)	Global
Rainfall	In-situ rainfall	Local

PRE-PROCESSING IN WEB-DHM MODEL

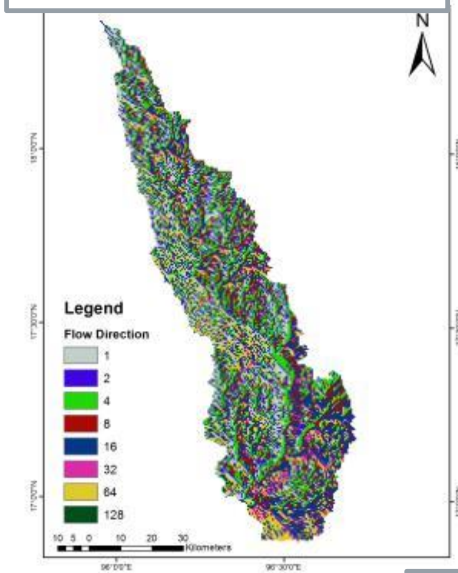
DEM



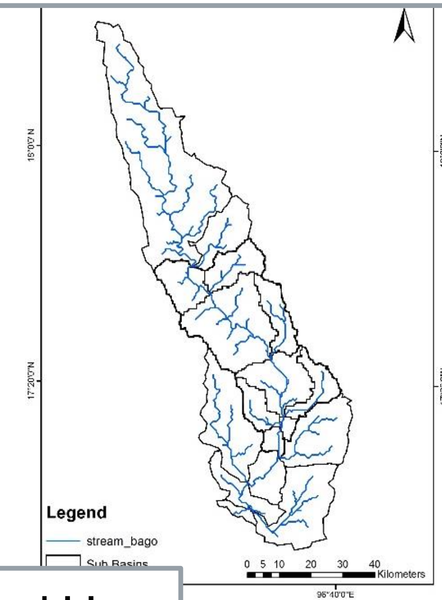
Flow Direction



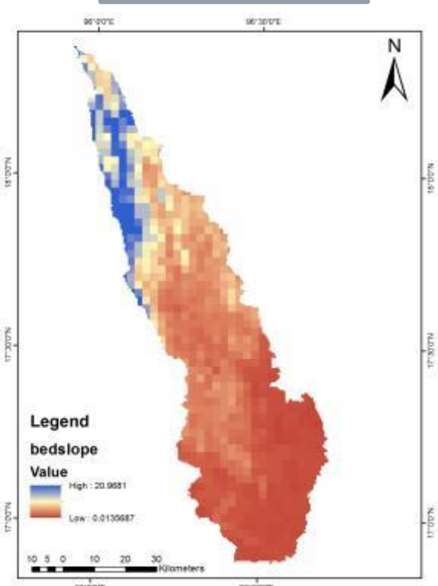
Flow Accumulation



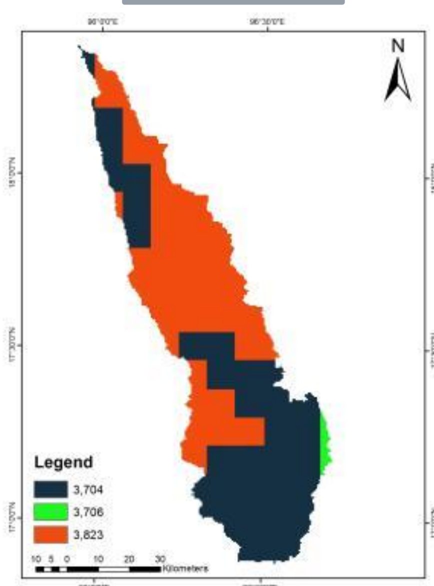
Pfafstetter 17 Sub basins



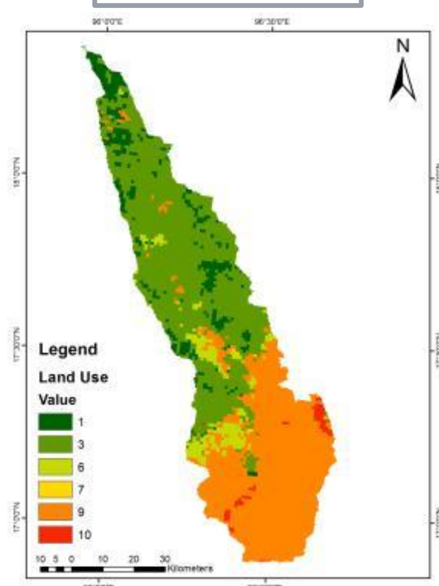
Hill Slope



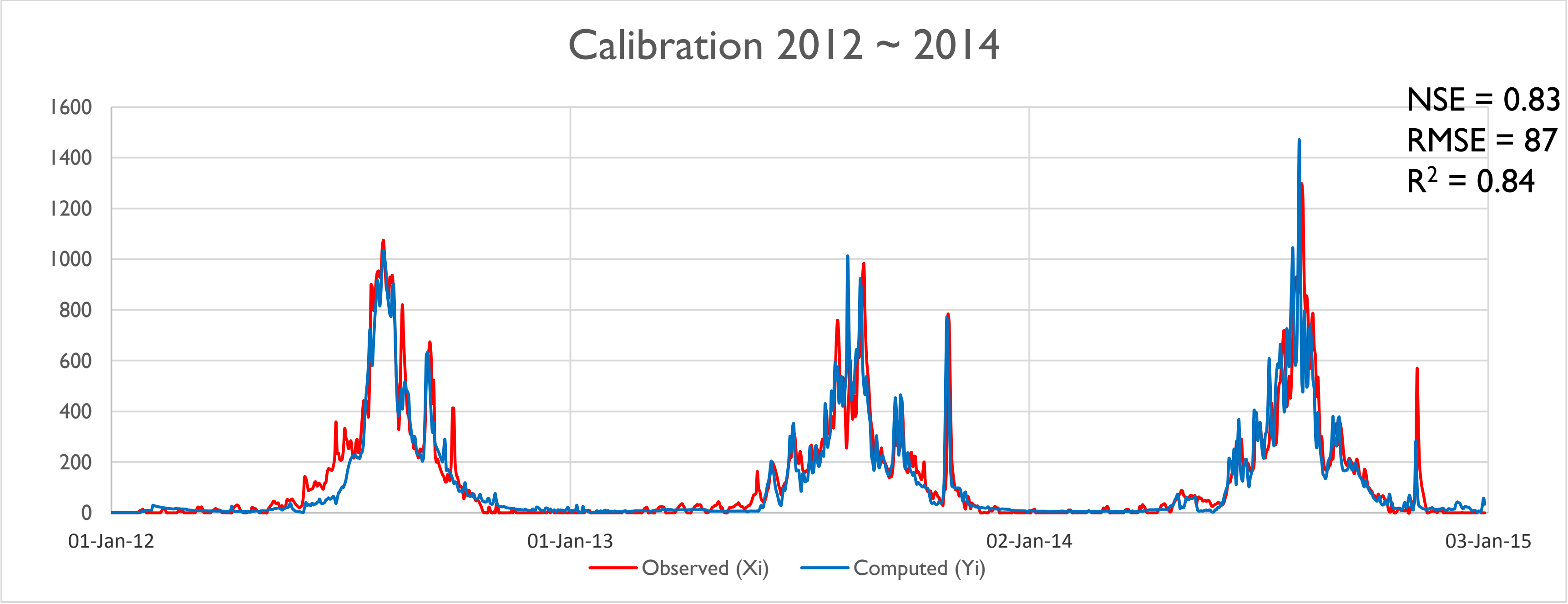
Soil



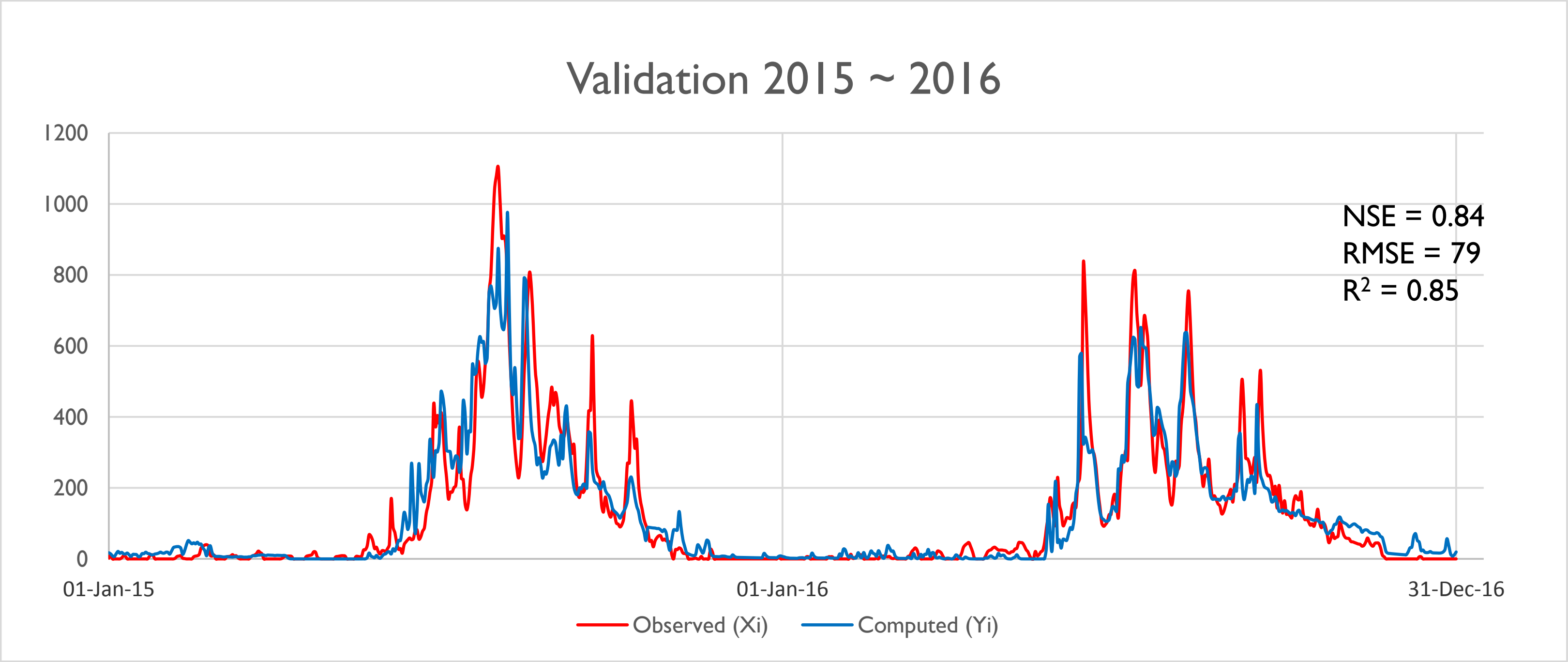
Land Use



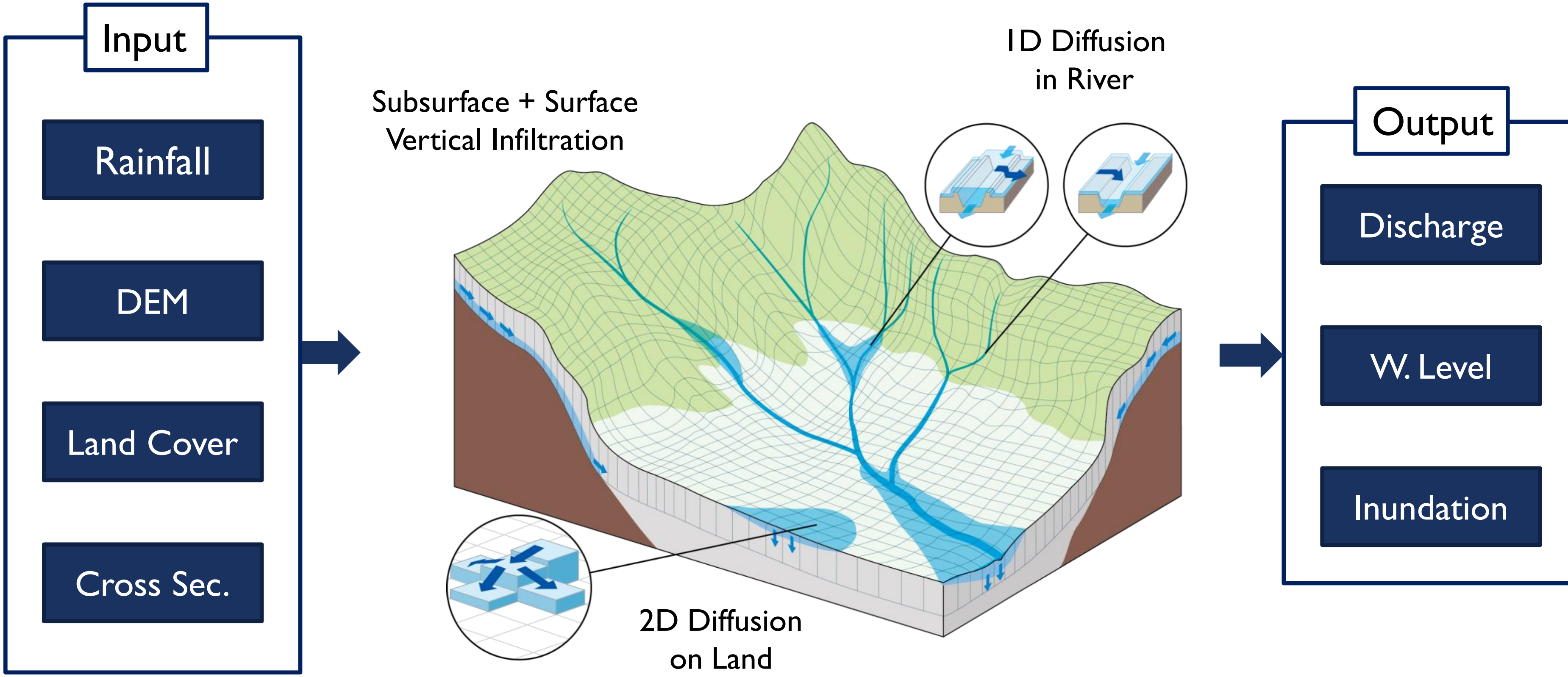
CALIBRATION
2012 ~ 2014



VALIDATION
2015 ~ 2016



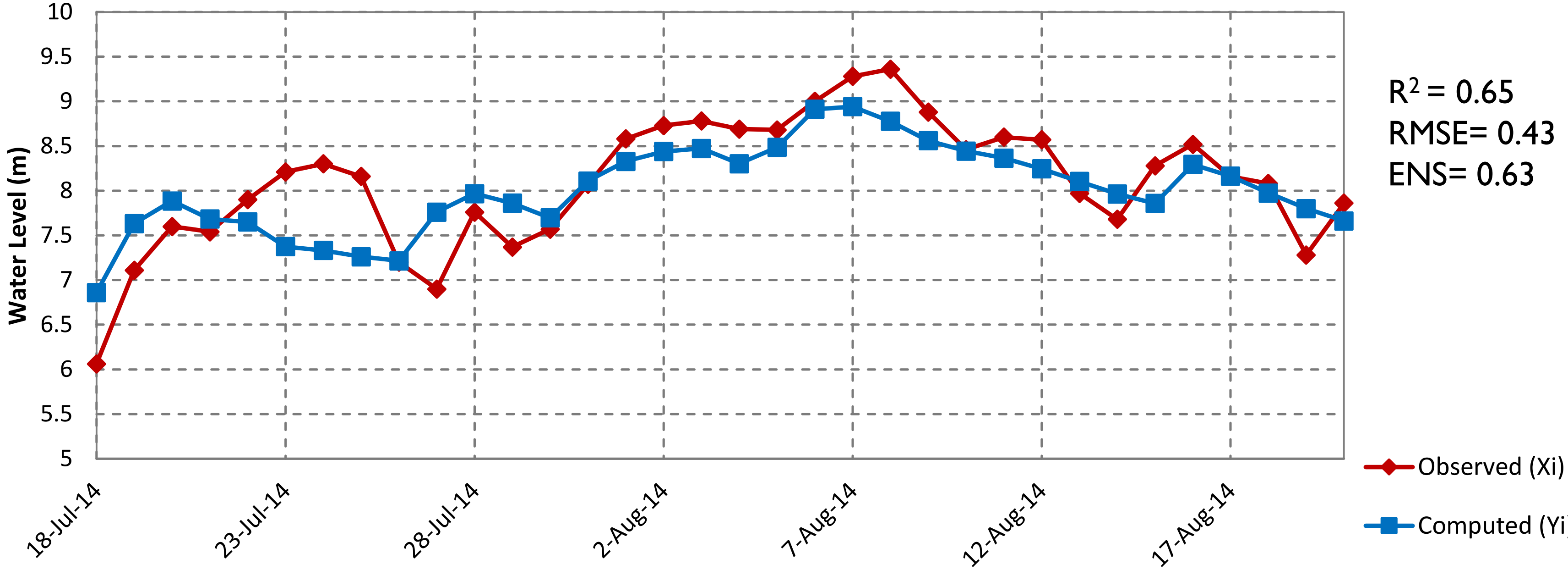
RAINFALL-RUNOFF-INUNDATION MODEL



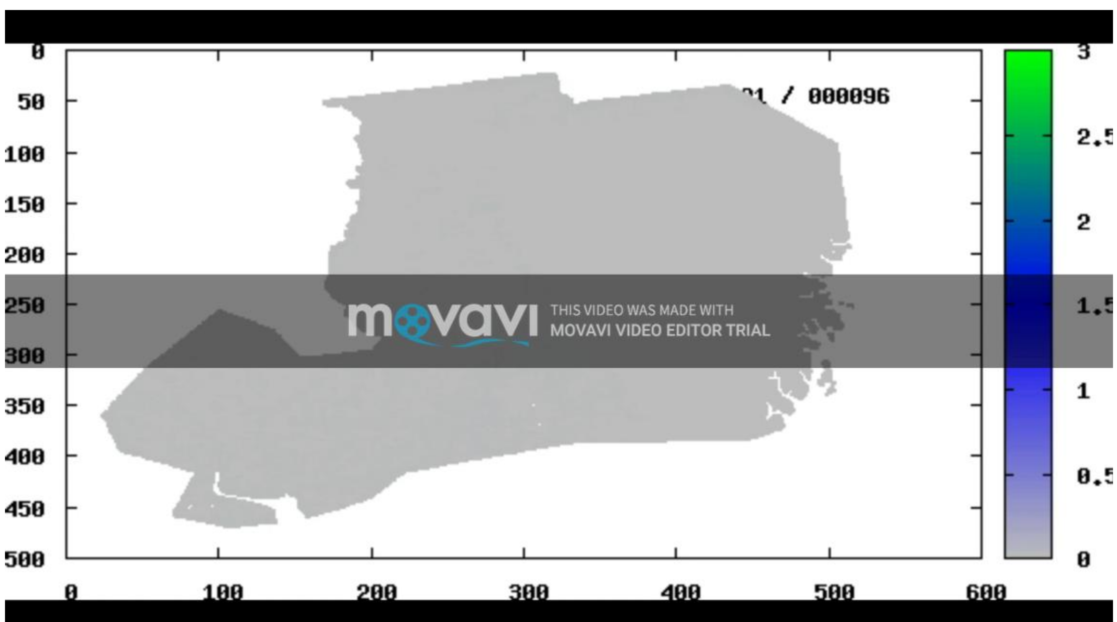
- Two-dimensional model capable of simulating rainfall-runoff and flood inundation simultaneously
- The model deals with slopes and river channels separately
- At a grid cell in which a river channel is located, the model assumes that both slope and river are positioned within the same grid cell
- Characterized as "Storage cell-based inundation model".

Sayama, T. et al.: Rainfall-Runoff-Inundation Analysis of Pakistan Flood 2010 at the Kabul River Basin, *Hydrological Sciences Journal*, 57(2), pp. 298-312, 2012.

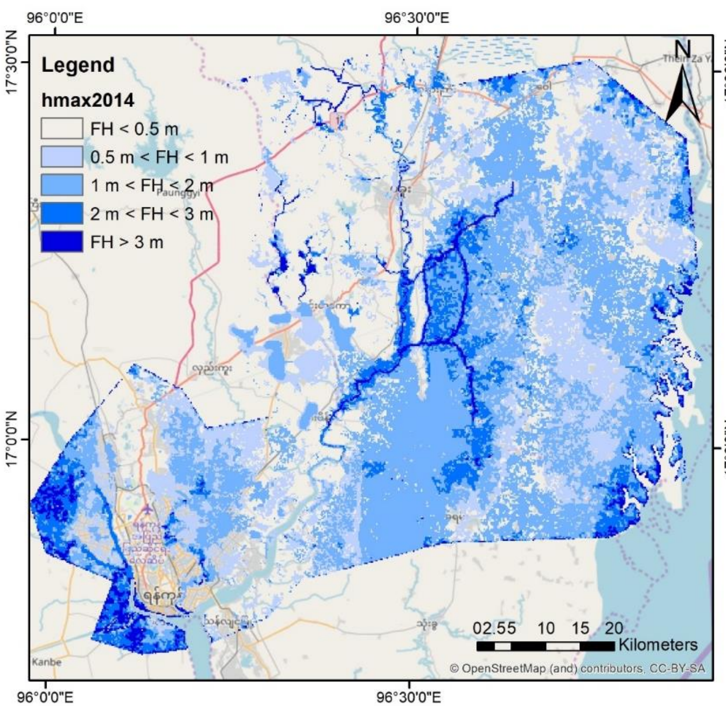
Comparison of Water Level at Bago Station (2014 Flood Event)



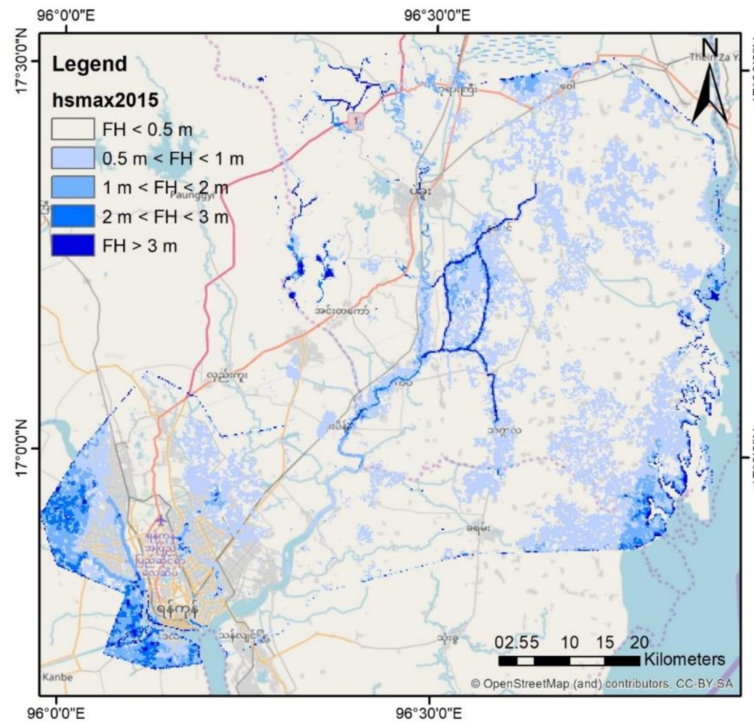
$R^2 = 0.65$
RMSE= 0.43
ENS= 0.63



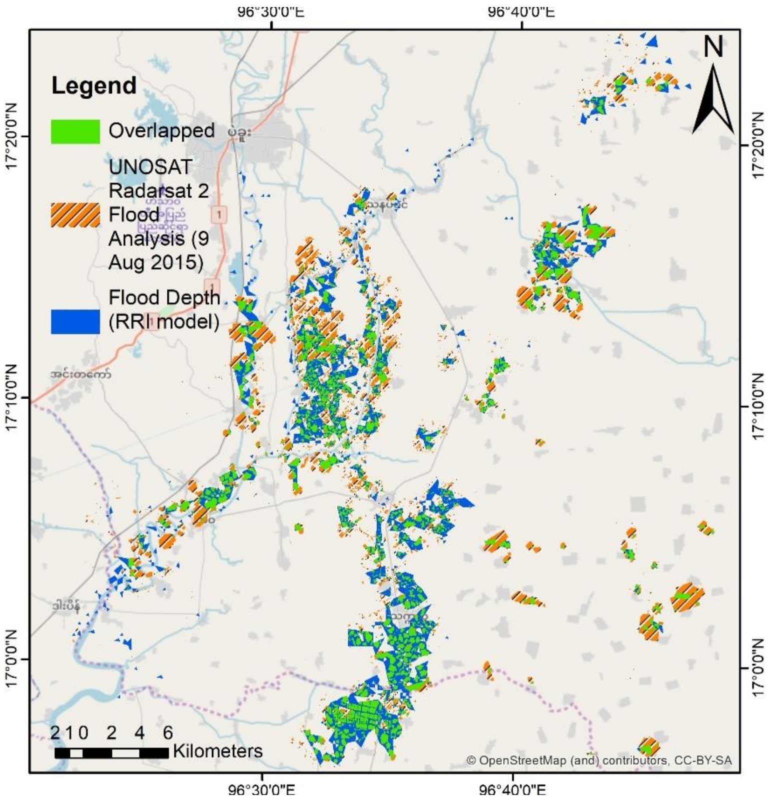
FLOOD INUNDATION MAPS



Simulated flooded area for 2014 August flood using RRI Model



Simulated flooded area for 2015 August flood using RRI Model



	Simulated by the RRI model	Observed by the Radarsat 2 image	Over-lapped	Over and Under estimated by the model
Flooded Areas (Ha)	127	130	75	55
Percentage (%)	97.4	100	58	42

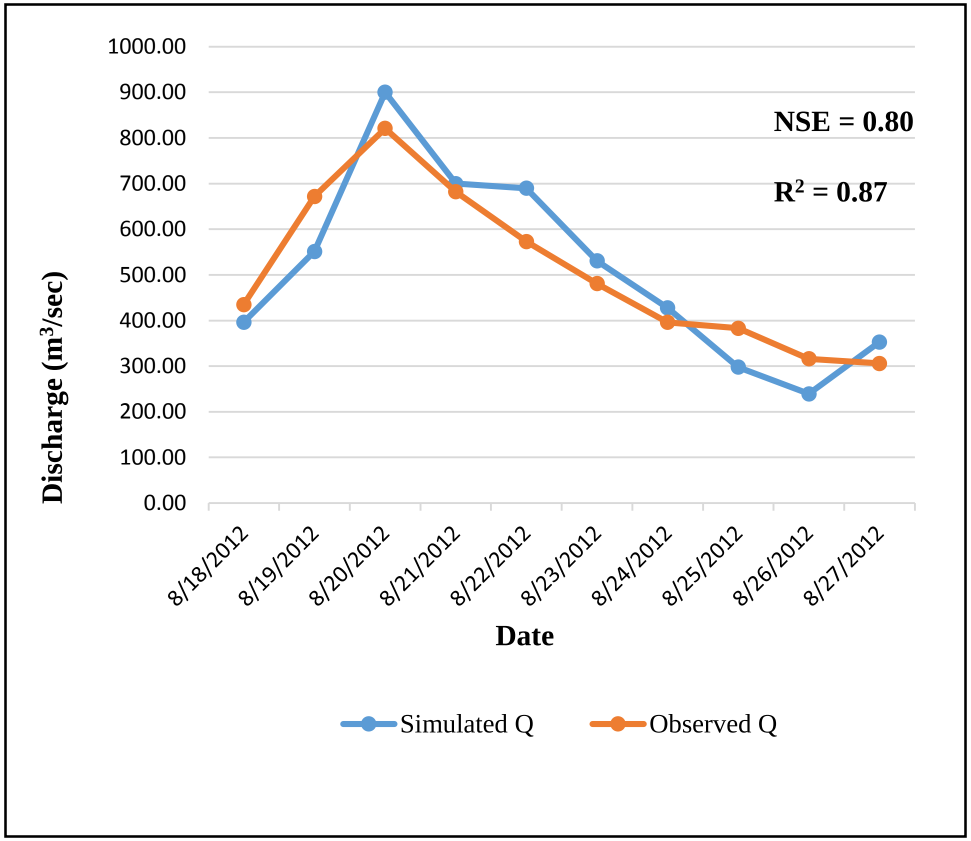
Comparison of 2015 flood inundation map with Radarsat 2 image

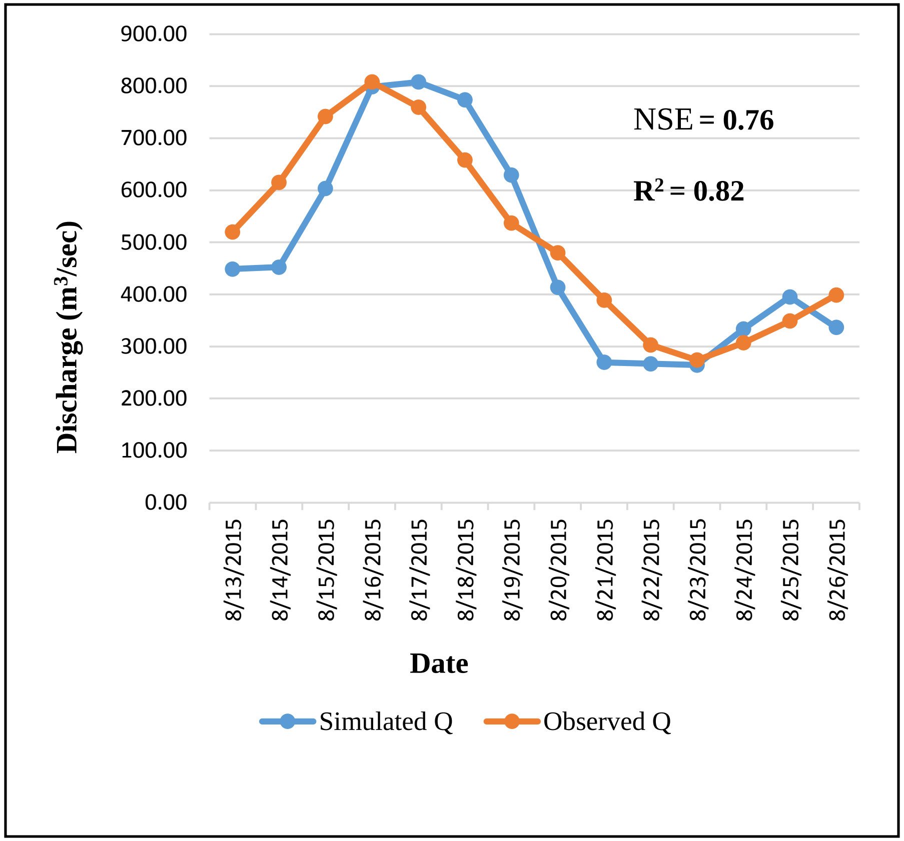
SOBEK 1D/2D MODELLING

- Developed by Deltares
- Hydrodynamics, Rainfall runoff and Real time control
- integrated software package for river, urban or rural management

Module / feature	SOBEK-Rural	SOBEK-Urban	SOBEK-River
Hydrodynamics			
1DFLOW	✓	✓	✓
Overland Flow module (2D)	✓	✓	
Hydrology			
RR	✓	✓	
Morphology			
1DMOR (incl Sediment Transport)			✓
Water Quality			
1DWAQ	✓		✓
2DWAQ			
Emission module			
Real Time Control			
RTC simulation module	✓	✓	

SOBEK Calibration Results

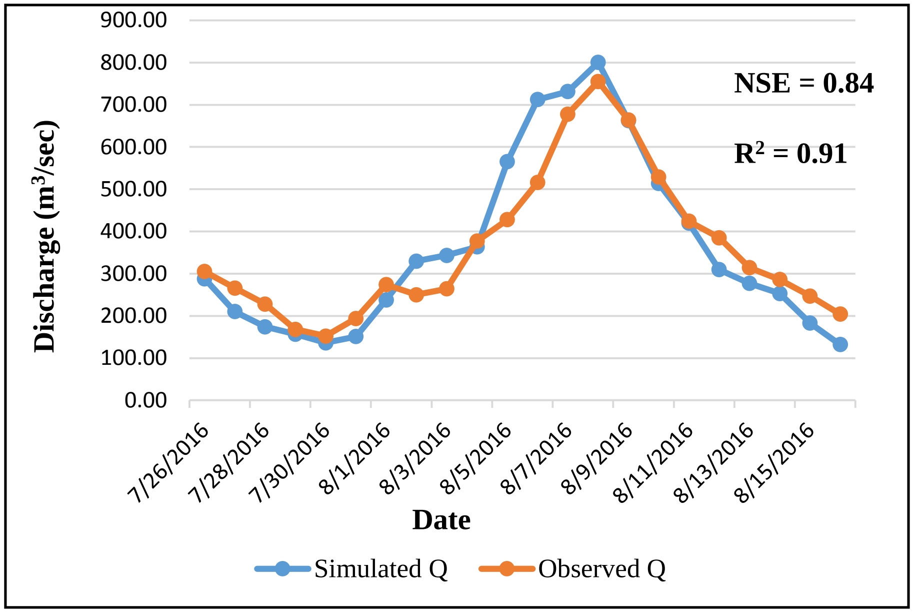




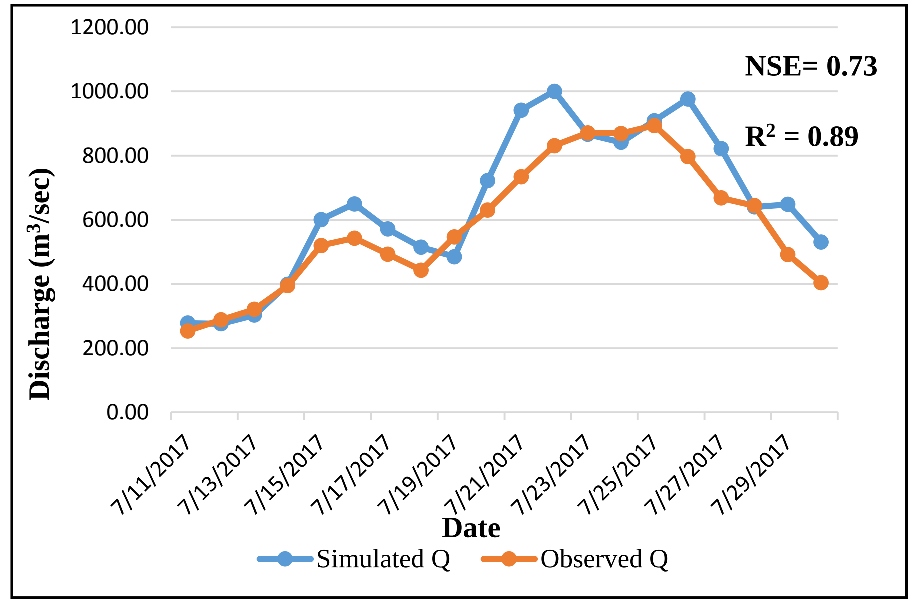
2012 August Flood Event

2015 August Flood Event

SOBEK VALIDATION RESULTS

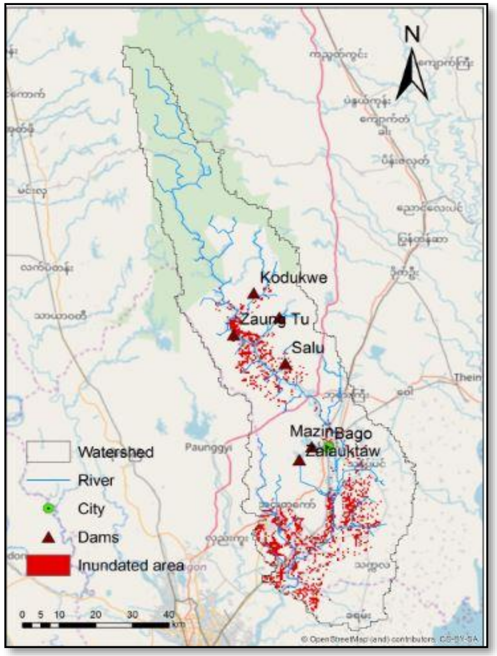


2016 July Flood Event

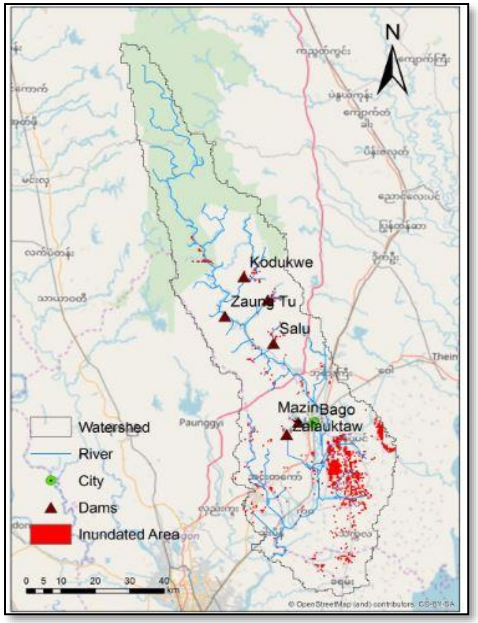


2017 July Flood Event

Comparison of Flood Inundation Area (2015 August Flood)



Flood Inundation Map for 2015 August Flood Event Using SOBEK Model



Flood Inundation Map for 2015 August Flood Event Developed from UNOSAT Image

SUMMARY

- WEB-DHM Model performs very well in model simulation. But current version is not user friendly yet.
- It was seen that HEC-HMS model performs well in model simulation. There was a close relationship between observed and simulated flow. And it is user friendly model.
- HEC-RAS model was found to fit satisfactorily.
- RRI model is suitable for data scarcity region. RRI-GUI use course resolution DEM and so resulted river pattern can not show with fine cells. User can easily apply RRI-GUI. In RRI-CUI, user can add high resolution DEM and so it can give accurate result than RRI-GUI. But RRI-CUI running time is so long, difficult for data preparation and it is not applicable in real time flood forecasting.
- It was found that SOBEK model is user friendly. Model results are satisfied . But this model is commercial software.

CONCLUSION

- Uncertainties in flood inundation mapping arise from many sources such as model mathematical background and configuration, model assumption, boundary condition, model parameters, input data, design discharge, topography, grid cell size, flow condition, water surface elevation, the gradients of the channel and floodplain, and Manning's roughness coefficients.
- Topographic datasets play a significant role in hydraulic modeling and the accurate prediction of flood inundation areas.
- The channel roughness also has a significant impact on hydraulic simulations.
- Accurate and reliable models are needed for developing flood inundation map.

SATREPS
WATER RELATED DISATER GROUP MEMBERS:

YTU

- Dr.Win Win Zin
- Dr.Zin Mar Lar Tin San
- Ma Thet Hnin Aye
- Ma Shelly Win
- Ma Kyu Kyu Thin
- Mg San Win Maung
- Mg Chit Bo Bo Win

University of Tokyo

- Professor Koike
- Professor Akiyuki Kawasaki
- Dr.Ralf Allen Acierto
- Dr. Seemanta Sharma Bhagabati
- ……………..
- ……………..

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