

HYDROLOGIC AND HYDRAULIC MODELING OF PANAY RIVER UNDER TROPICAL STORM BOLAVEN 2018 RAINFALL EVENT FOR FLOOD MAPPING OF PONTEVEDRA, CAPIZ, PHILIPPINES

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ABSTRACT

In 2018, Tropical Storm Bolaven (local name Agaton) brought massive flooding and caused millions of damages in agriculture and fisheries in the Province of Capiz, Philippines, where 12 out of 16 municipalities were affected, including the town of Pontevedra. This study aims to estimate flooding in the town of Pontevedra under Tropical Storm Bolaven 2018 by performing hydrologic and hydraulic modeling using HEC-HMS and Nays2D Flood, respectively. The hydrologic model is developed for the Panay River basin and the hydraulic model is applied to the political area of Pontevedra and neighboring municipalities. Calibration of a gauged Panay River sub-basin using the rainfall data of Tropical Storm Kaitak (local name Urduja) in 2017 and the corresponding discharge data at Dao Bridge is used to determine hydrologic parameters which are then applied to ungauged river sub-basins. The result of the hydrologic modelling for TS Bolaven 2018 rainfall yields a peak discharge of 1,700 m³/s at Panitan Bridge, which serves as the inflow discharge to the hydraulic model of Pontevedra using the Nays2DFlood solver of the iRIC software. Results of the hydraulic model is validated using the flood extent of TD Agaton from situational reports. The generated flood extent and flood map for TS Bolaven in this study is used to provide recommendations of flood mitigating measures in the town of Pontevedra, Capiz, Philippines.

Keywords: Flood Map, HEC-HMS, Nays2D Flood, TD Agaton, Pontevedra

1. INTRODUCTION

1.1 Background of the study

Flooding is one of the major problems in the Philippines. It is usually caused by heavy rainfall brought by typhoons and monsoons. There are at least 20 typhoons that enter the Philippine Area of Responsibility every year (PAGASA, 2019). One of the most recent flooding events in the Province of Capiz was caused by Tropical Storm Bolaven (local name Agaton) that occurred on January 2018. Most of the towns were flooded, thousands of families evacuated, and damages in agriculture and fisheries were recorded. According to the reports of the Provincial Disaster Risk Reduction and Management Office (PDRRMO) of the Province of Capiz, 12 out of 16 municipalities in the province were flooded. From the said municipalities, 159 barangays were affected and a total of 1,482 families went to evacuation centers; 232 of which is from the Town of Pontevedra. The town of Pontevedra is located at the downstream area of the Panay River which has a catchment area of 1,985 km², and is situated near the coast in the Panay Island, Philippines.

This study aims to simulate the flooding in the Town of Pontevedra under Tropical Storm Bolaven 2018 and to create a flood map that could be used for analysis and recommendation of possible mitigating measures for flood prevention and planning of the local government unit of Pontevedra. This study also aims to create a hydrologic and hydraulic model which could be used for the simulation of other extreme and future rainfall events of the Town of Pontevedra. This study uses the Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) software for the hydrologic model and the Nays2DFlood version 5.0 model of the International River Interface Cooperative (iRIC) software for the hydraulic model. A study conducted by Shaieqfrotan et al. (2018) showed that Nays2DFlood solver produced simulated results that are in considerable agreement with the observed flooding extent using available topographic data and is a useful tool in flood prediction and delineation.

2. METHODOLOGY

2.1 Data Gathering

The primary topographic data with a 10-meter resolution used in the modelling of the Panay River Basin was gathered from the University of the Philippines Disaster Risk and Exposure Assessment for Mitigation (UP DREAM) Program. The land cover map was obtained from the National Mapping and Resource Information Authority (NAMRIA) and the soil map was gathered from the Bureau of Soils and Water Management (BSWM). Rainfall data used in the simulation was obtained from the Department of Science and Technology – Advanced Science and Technology Institute (DOST-ASTI). The river discharges used in the calibration of the model were collected from the Department of Public Works and Highways (DPWH) and UP DREAM.

2.2 Hydrologic Modeling

The hydrologic model for the Panay River Basin was developed using the HEC-HMS software. This study implemented the SCS Curve Number method for the loss model, the SCS Unit Hydrograph method for the transform model, the Exponential Recession Method for the baseflow model, and the Muskingum Routing method for the river reach routing model. The HEC-HMS hydrologic model of the Panay River is shown in Fig. 1(a), with a total of 73 sub-basins and 50 reaches. Discharge data was only available at Dao Bridge during Tropical Storm Kaitak 2017 and this discharge data with the corresponding available rainfall data were used to calibrate portion of the hydrologic model. The location of Dao Bridge is shown in Fig.1(b) and the observed data and simulated discharge are presented in Fig. 2(a). The calibrated hydrologic parameters were then applied to ungauged sub-basins that have the same characteristics with the calibrated basins of the Panay River hydrologic model. The rainfall data of Tropical Storm Bolaven 2018 from DOST-ASTI stations, shown in Fig.1(c), were then used to simulate the discharge at Panitan Bridge which serves as the upstream boundary condition of the hydraulic model. The simulated discharge is presented in Fig. 2(b) and the peak discharge is at 1,700 m³/s.

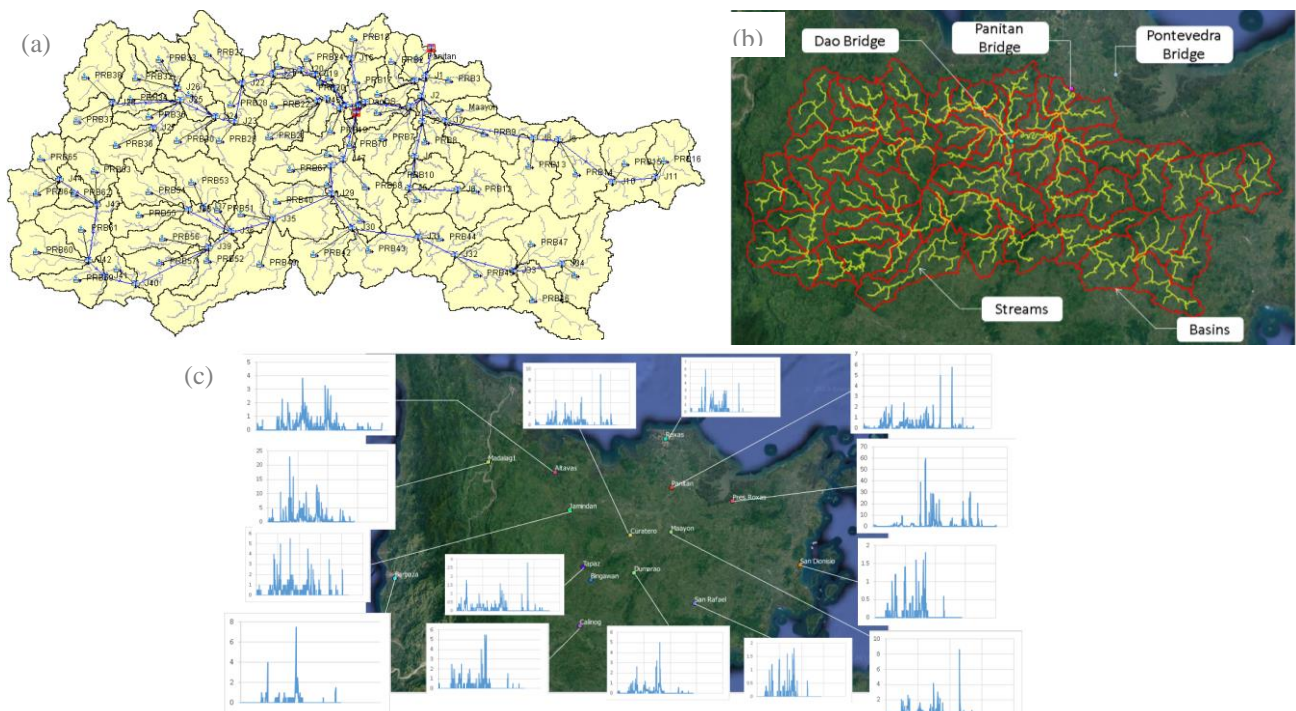


Figure 1. (a) Hydrologic model of Panay River, (b) Location of Dao Bridge and Panitan Bridge in the river basin, and (c) locations of rainfall stations and rainfall data of Tropical Storm Bolaven 2018.

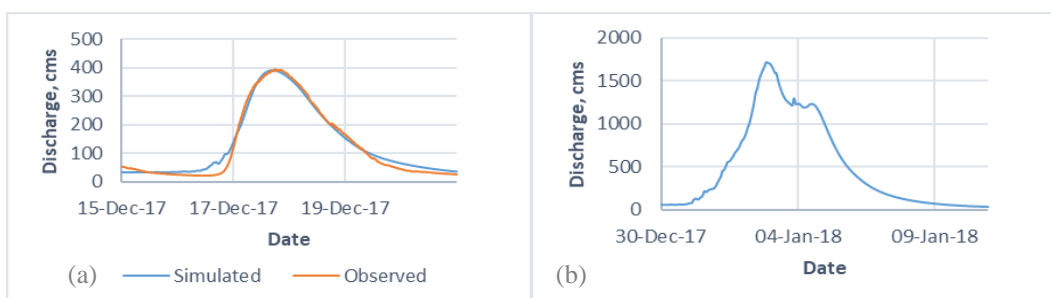


Figure 2. (a) Simulated and observed discharge of Tropical Storm Kaitak (Urduja) 2017 at Dao Bridge, and (b) simulated discharge of Tropical Storm Bolaven (Agaton) 2018 at Panitan Bridge.

2.3 Hydraulic Modeling

Nays2DFlood solver of the iRIC software was used to perform hydraulic modeling downstream of Panitan Bridge. Nays2DFlood solver relies on unsteady 2-dimensional plane flow simulation using boundary-fitted coordinates as the general curvilinear coordinates (Shimizu et al., 2015). The topographic data from UP DREAM was used to develop the hydraulic model which has a resolution of 50 meters. The land cover data from NAMRIA was used to determine the Manning's roughness of the hydraulic model. The simulated discharge data of Tropical Storm Bolaven 2018 at Panitan Bridge was used to simulate the flooding. The simulated flood extent was validated with the reported flooded areas from the PDRRMO of Capiz.

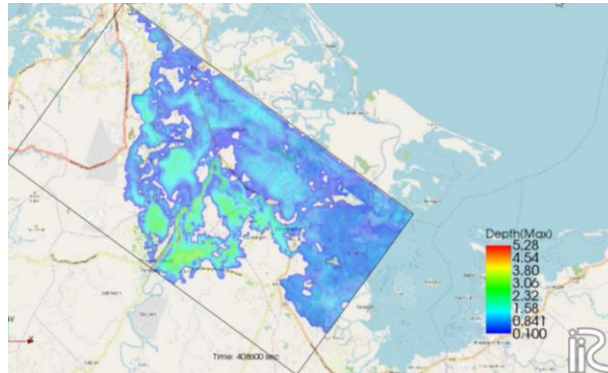


Figure 3. Simulated flood depths and flood extent using TS Bolaven 2018 simulated hydrograph at Panitan Bridge

3. RESULTS AND DISCUSSION

The flooding in the town of Pontevedra due to Tropical Storm Bolaven 2018 was hindcasted by performing hydrologic and hydraulic modeling. This was accomplished through the use and processing of secondary data from agencies. Through numerical modeling using HEC-HMS hydrologic model and Nays2DFlood hydraulic model, the flood map for the Town of Pontevedra due to TS Bolaven 2018 is generated as shown in Fig. 4. Almost all of the areas in the Town of Pontevedra were flooded. Maximum flood depth occurs at areas near the Panay River and at high flood depths are observed at flat terrains near the coast. Areas with low flooding should be utilized for evacuation centers in case of flooding. It is recommended that the effects of river flood walls and upstream detention reservoirs that could prevent flooding in the area should be investigated through numerical modelling.

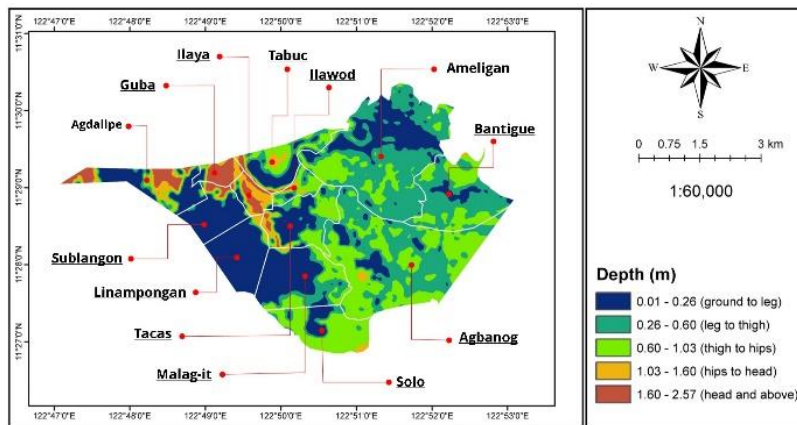


Figure 4. Flood map of the affected barangays in the Town of Pontevedra, Capiz, Philippines

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