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Flood zoning estimation and river management by using HEC-RAS and GIS model

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ABSTRACT: Reliable estimates of river stream flow and flood zoning maps are needed for water resources management such as flood mitigation, water supply, dam construction and irrigation. Flood zoning needs accurate data and is one of the non-structural flood management methods. This paper describes the application of HEC-RAS and GIS model to determine floodplains maps for the part of Sardabrud River that lies in Mazandaran province (Iran). Results obtained by HEC-RAC model were used in combination with GIS to prepare flood zoning maps for different return periods. For this purpose, the geometrical plan of the river was prepared with the aid of HEC-RAS software and through regional topography data. After importing the data to HEC-RAS model, flood phenomenon was simulated in 2, 5, 10, 50, 100, 500, and 1000 years return periods. Through flood zoning maps, areas that are vulnerable to flooding hazards have been identified. Analysis of flood zoning maps indicated that more than 168 square kilometer is likely to be inundated as compared to the normal flow of the river. Also results of the current study indicate that depth of flow is happened in 1000-year return period and 163 meters respectively.

Keywords: *Flood mapping; Flow depth; Mazandaran; Return periods; Water management*

INTRODUCTION

The estimation of stream flow characteristics for a site without historical data is one of the fundamental works in flood zoning. In many situations, flood zoning data needed for planning dam construction, operation of water resources systems and flood forecasting purposes (Abghari and Mohseni Saravil 2007) .Prediction of river hydraulic characteristics in contrast to probable flooding for reducing damages is essential. Allocating of flooding locations near the cities is one of the basic data for controlling floods in a non-structural manner (Behdarvandi Askar *et al.,* 2010). Although by structural manner in flood control estimating discharge and balance of water is possible, its function has not been satisfactory during the recent decades and experts believe that if structural manners are combined with non-structural manners, it can minimize the flood damages (Birkland and Burby 2003). Empirical models using regional physiographic and hydro meteorological variable are not available or the data record is too short to make any meaningful decision (Cook and Marvade 2009). Several hydraulic models have been developed for estimating flood zoning such as MIKE, HEC-RAS, INFOWORK ISIS, and etc (Hassanpour *et al.,* 2012). HEC-RAS model can be referred as one of the strongest flow river flow simulator software. At present time, using GIS model and HEC-RAS hydraulics software is model most commonly method to describe the relationships between surface flooding and the depth of flow according to return period (Karimain Kakli *et al.,* 2013). Some researches studied effect of topography data and geometrical state on flood maps by means of HEC-RAS and GIS software (Kia and Pirasteh 2012). Also HEC-RAS makes a remarkable contribution to development of geometrical data for entry into software and also represents water surface

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profile and flow characteristics (Knebl andYang 2005, shahiri Parsa and Vuatalevu 2013) . Tate *et al.,* (2002) implemented a model for preparing the flood zones using HEC-RAS and GIS model for Waller River, Austin-Texas (USA).

This paper attempts to determine river privacy regional producing floods and flood zoning maps of Sardabrud River (Mazandaran – Iran) utilizing HEC-RAS model and ARC GIS software.

MATERIALS AND METHODS

Sardabrud River

Sardabrud River is one of the branches of Chalus River located on the Mazandaran province (Iran). The river emanates from Kelardasht Mountain located on north Chalus city. The catchment area of Sardabrud River is 419.25 square kilometers and the average discharge of river is 3.6 cubic meters per second. The average slope of Sardabrud River is 0.019. Table 1 shows the topography characteristics of Sardabrud watershed.

Also Fig. 1 shows the main flow river topographic map.

The design discharges based on return periods of flow demonstrated in Table 2.

Fig. 2 demonstrates longitudinal profile of Sardabrud River.

HEC-RAS model

The results of the studies on simulation river phenomena by American Military Engineering had been producing river modeling software HEC-RAS. The one- dimensional models consists of six sub-model for flow characteristics , hydrological calculations , dam reservoir planning , simulation monthly river flows, utilizing management of the reservoirs and morphological changes of the river bed due to sedimentation . HEC-RAS is a one–dimensional model which can simulate flow conditions on steady and unsteady states. In steady states, HEC-RAS model calculates water surface elevation and velocity in cross sections by solving the energy continuity equations and flow resistance. The method is based on the energy relationship that starts the calculations from supercritical flow at upstream to sub critical flow at downstream.

Table. 1: Topography characteristics of Sardabrud watershed

Characteristic	value
Area (square kilometer)	419.25
Perimeter (kilometer)	177.0
Length (kilometer)	48.53
Average Width (kilometer)	8.64
Gravelious index	2.43

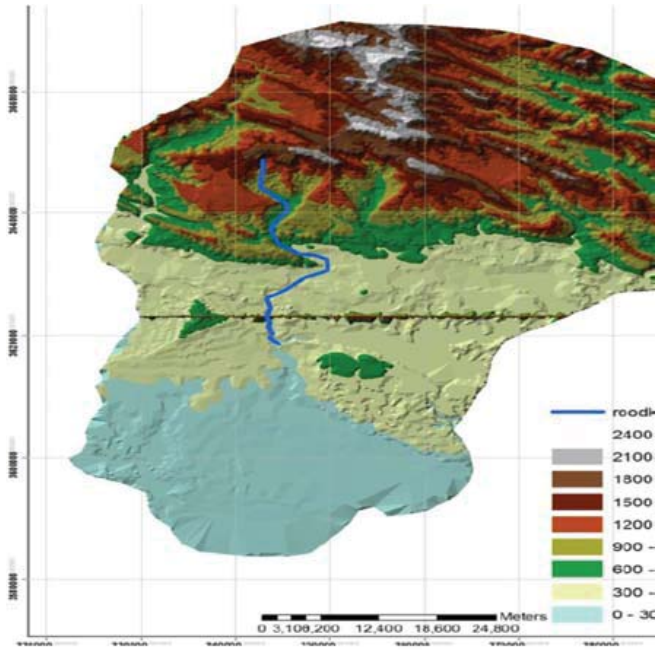

Fig.1. Topographic map of Sardabrud River

Table. 2: Design discharges based on return periods of flow

Return period (year)	2	5	10	20	25	50	100	500	1000
Discharge (cubic meters per second)	12	18	24	29	36	50	65	150	190

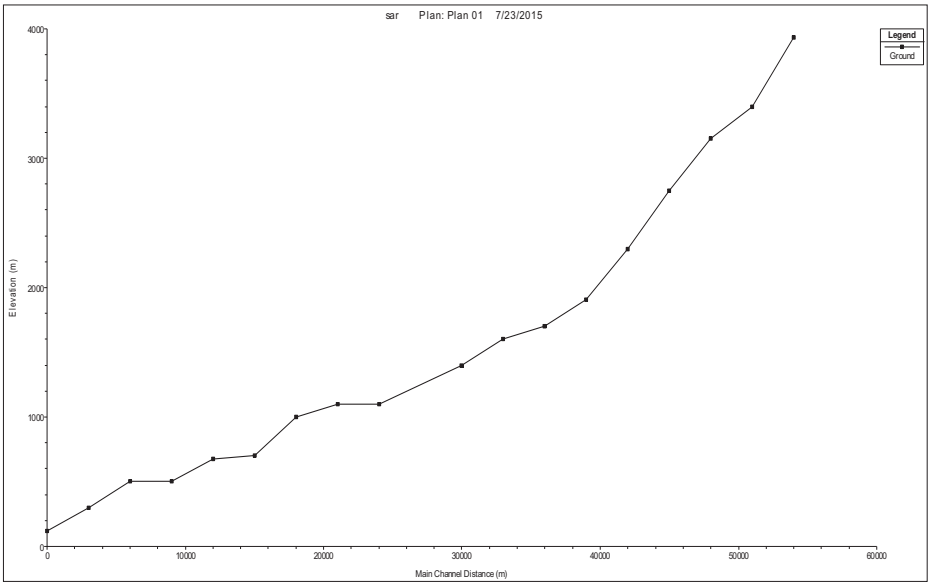

Fig. 2: Longitudinal profile of Sardabrud River

Fig. 3. Simulation of cross section in HEC-RAS

The required data for HEC-RAS model includes topography data, Manning's roughness coefficient and flow data concluding flow rate, boundary conditions and etc. Topography data was considered as the form of a set of cross sections which is shown by Fig. 3.

The cross section prepares the distances where significant changes have accrued roughness coefficient and river slope (Fig. 4).The cross sections are chosen perpendicular to the flow.

RESULTS AND DISCUSSIONS

After preparing geometric layers of the river in ARC-GIS software, data inputs in HECRAS models (Fig. 5).

Flood zoning maps for floods with return periods of 2, 5, 10, 50, 100, 500, and 1000 years were obtained. For briefing the results only 2 years return periods flood has been demonstrated (Fig. 6).

Fig. 7 shows the location of flood retention zone from the route topographical features.

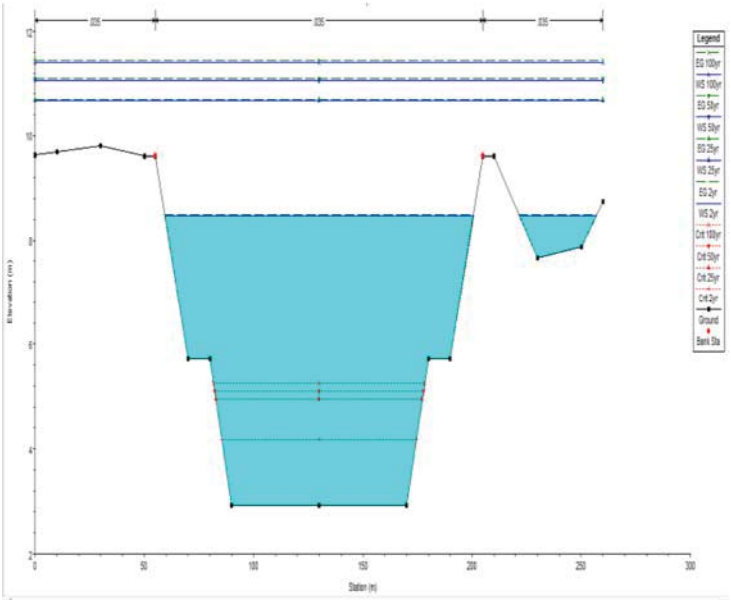

Fig. 4: Cross section profile of Balarud River

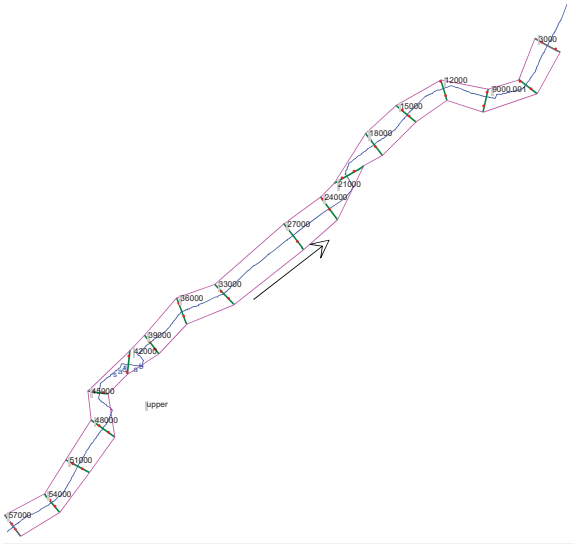

Fig. 5: Data transferring of the river from ARC-GIS to HEC-RAS

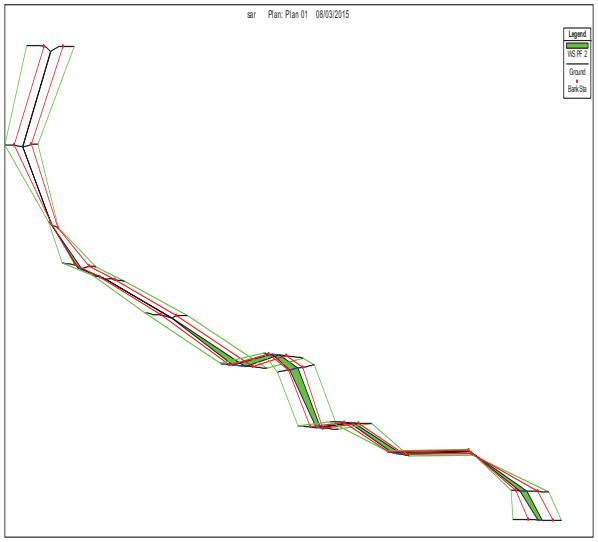

Fig. 6: Running program for 2-year return period

Every width of the stream bed is increased, width of the flood plain is also increased and water is spread over a large surface (Fig. 8).

Zoning of flood generated by the HEC-RAS model can be easily created for other different floods and transferred to ARC GIS program and placed on the Transferred Irregular Network (TIN). Food zone area and damages can be calculated and the results are important especially for dam construction and water management resources. Studies have shown that the maximum surface flooding and depth of flow is happened in 1000-year return period flood, 168square kilometers and 163 meters respectively.

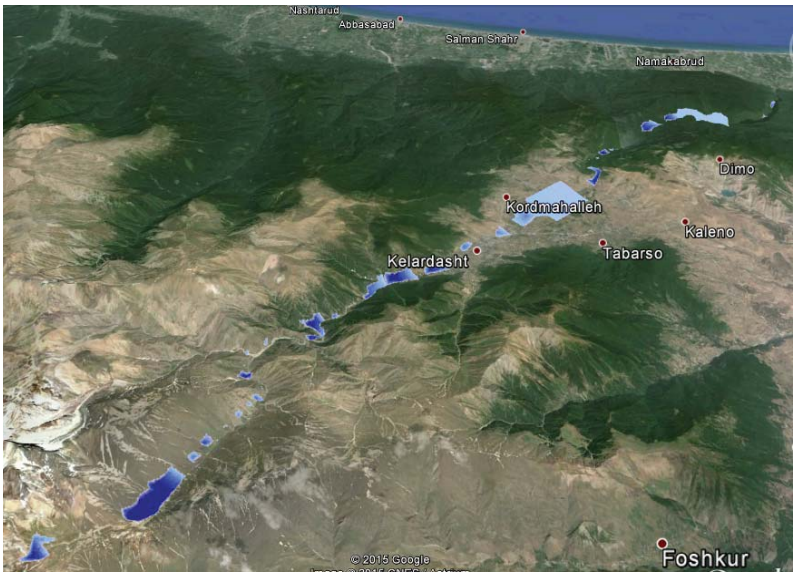

Fig. 7: Location of flood retention zone for 2-year return period

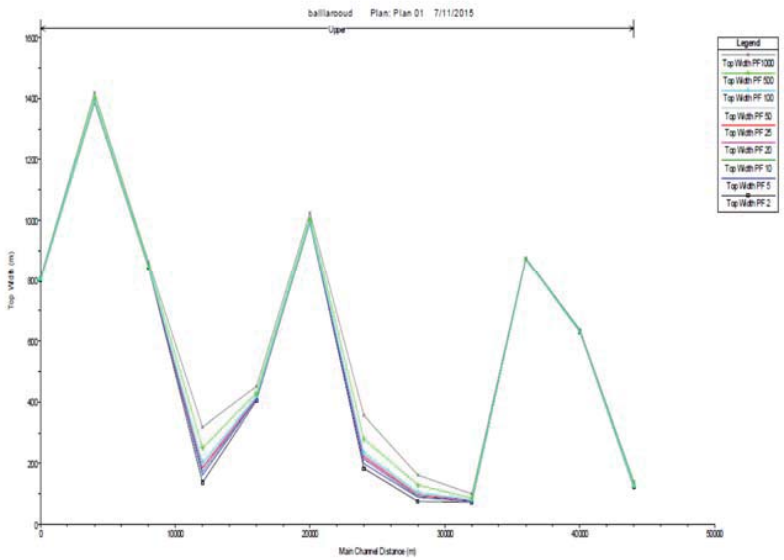

Fig. 8. Variation of the water width profile in Balarud River

CONCLUSION

In the present study flood zoning of Salarud River flow in Mazandaran province, north of Iran, conducted by HEC-RAS model and GIS software. For modeling flow river, return periods of 2, 5, 10, 50, 100, 500, and 1000 years were used. The maximum surface flooding and depth of flow were happened in 1000-year return. Modeling can appear as a regional warning system to reduce the risk and for flood simulations studies in town and regional levels and also distinguish the places which are in need of structural measures along the river.

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