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On the Hydraulic Simulation of River Simineh Using HEC-RAS and ArcGIS Software

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1-Introduction

As the country Iran is located among arid and semi-arid regions, the proper management and use of water resources are seen one of the ways to adapt to such conditions; this requires the appropriate use of surface and groundwater resources and a better understanding of hydrological phenomena (Alizadeh, 2015: 36). Rivers are one of the important sources of water that should be considered and also protected according to their significant role in human life. Generally, rivers are constantly evolving (Winterbottom, 2000: 199). The characteristics of river hydromorphology are affected by such factors as flooding, tectonic motions, dams, climatic changes, land-use and human intervention. Those changes, either physical or morphological, which are due to the natural or abnormal factors effect (Shayan et al., 2017: 29). In order to calculate the total flow transmission by HEC-RAS model, adding discharge under main channel and floodplain using Manning's resistance equation according to $Q = \frac{1}{n} AR^{2/3}S^{1/2}$, where Q is the flow rate, n is the Manning's roughness coefficient, S is the energy grade-line, A is the cross-sectional area and R is the hydraulic radius (Mohammadi, 1398:52). In addition, the HEC-RAS hydraulic model has virtuous capability for the analysis of flow hydraulics in this study; based on the flow rate data at available stations, the required sections and other necessary information are simulated in a range of River Simineh. So far, numerous studies on the flood have already been studied, but the study of simulation of River Simineh catchment have not been considered by using satellite images and integration of HEC-RAS model and GIS. And one of the distinguishes in present research is modeling one dimensional simulation of flow velocity in transverse sections. The results of this study, in addition to the scientific community of civil engineering and water engineering, are

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important for experts and planners in the region and in the area of crisis management, flood management and update information required by the executive machines.

2-Methodology

The study area is River Simineh extensively in the area of Bukan county, West Azerbaijan province, Iran. The River Simineh basin is located in latitude 45˚to 46˚20′ East, 36˚20′ to 37′ North. And it has the area of 3726 km^2, the average annual rainfall at altitudes is 467.3 mm and in the plain is 339.1 mm, the temperature at altitudes is 10.6 and in the plain is 12℃. The data parameters used in present study are: flow rate, water level and meteorological parameters at Kavalan, Dashband Bukan and Siminerud stations from regional water authority and meteorological organization of west Azerbaijan province. The following research procedures are:

1- Preparing the elevation map with accuracy of 10 m from the US Geological Survey;

2- Extraction of the Triangular Irregular Network (TIN) and stream network;

3- Preparation of flow surface in river using 2D flow tool by HEC-GeoRAS extension in GIS background;

4- Using SA/2D Area BC Lines tool for the upstream and downstream of the river;

5- Determination of floodplain mound by using a flow path layer for the river cross sections;

6- The completion of work in HEC-GeoRAS and starting the simulation in HEC-RAS;

7- To evaluate the flow velocity and depth in river bend by integrating satellite images and HEC-RAS model;

8- And finally, validation of the model by using some usual statistical approaches.

3- Results and Discussion

The maximum and minimum elevations of the River Simineh basin are 2559m and 1269m, respectively. A TIN layer composed of the most useful layers in the performance of HEC-RAS model. In present study, 58 cross sections on the river lane have been provided for investigation. The range of water depth variation is from 1 to 3.5 m and the flow velocity varies from 0.5 to 3 m/s in the case study area. The flow discharge and water level were calculated upstream are 316.3 m^3/s and 12.85 m, respectively; and the downstream values of flow discharge and water level are 313.6 m^3/s and 11.52 m,

respectively. The flow depth before and after the river bend are 2.54 m and 2.96 m, respectively; and at the inner bend is 3.24 m. The maximum velocity vectors occur in the areas close to the outer bend, which exacerbates erosion. Also, the analysis of results showed that the flood zone in 10-year return period equals 363.89 km^2 and in 25-year return period is 643.40 km^2 of the surrounding lands that will be under the water. The value of modeling variance in comparison with the variance of observational data, Nash-Sutcliffe Error (NSE) coefficient value for such parameters as water level and flow depth were 0.805 and 0.845, respectively; which shows the high accuracy of the model results. Also, the root mean square error (RMSE) was calculated for the flow rate of 19.14 and the water surface level was 0.14. To increase the uncertainty of the simulation results of flow depth and velocity by the model, from satellite images and GIS outputs in preparation of the altitude map in a synthesis of HEC-GeoRAS, which is compatible with the results of such researchers as Termini (2021). To validate the model, the NSE coefficient for flow rate and water surface level were calculated to be more than 0.80, which states the high accuracy of simulation by the model and confirms such results given by Zahiri and Ashenavar (2021).

4- Conclusions

In general, the results of present research indicate that limiting the flow channel in points leads to increasing flow depth and in other points due to increasing flow velocity along the river lane. This will result flood at the adjacent fields or the waterlogging phenomenon of the river bed as well as the river banks. In both cases, significant changes have been made in the water morphology of the river, including the change of flow path along the river or the erosion of the river affected by the erosion of the banks and the change of river bed slope due to the erosion phenomenon. The results of the HEC-RAS hydraulic model indicate the ability of the model to determine the hydraulic status of the flow in the study interval. According to the obtained values of NSE coefficient for both the flow rate and water level were calculated more than 0.80 which expresses the high accuracy of the method used in the simulation. According to the original geometric information, ArcGIS and HEC-RAS software both have high capabilities in floodplain management and increasing the accuracy, speed; and reducing the cost of river engineering studies.

Keywords: Hydromorphology, River Simineh, flow simulation, NSE coefficient, HEC-GeoRAS, ArcGIS, Northwestern Iran.

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