University of Tabriz

Journal of Civil and Environmental Engineering
Volume 51 (2021), Issue 2 (Summer), 63-72

EXTENDED ABSTRACT

River Flow Simulation by Integrating Numerical Methods and Satellite Images

Javad Zahiri *, Mehran Ashnavar

Department of Water Engineering, Agricultural Sciences and Natural Resources University of Khuzestan, Ahwaz, Iran

Received: 20 April 2018; **Accepted:** 15 July 2019

Keywords:
River flow simulation, Numerical model, Satellite images, River bend, Nash-Sutcliffe coefficient.

1. Introduction

Numerical models have the ability to simulate river flow by using mathematical relations under certain initial and boundary conditions. Investigating the capability of different models for simulating flow characteristics in a river reach such as flow depth, velocity and shear stress in river banks are one of the basic needs in river engineering. However, from the practical point of view, the minimum need for field information, the small computation, and the degree of trust of the application of mathematical models in the conditions of natural rivers is of great importance. The aim of this study is to integrate GIS and HEC-GeoRAS with HEC-RAS model in order to simulate the hydraulic parameters of the Karun River in Khuzestan province.

2. Methodology

Data used in this research were provided by Khuzestan Water Power Authority (KWPA). This information includes Karun river cross sections, the flow discharge and the level of water at three stations of Mollasani, Ahvaz and Farsiat. The digital elevation model (DEM) used for this study was obtained at an accuracy of 30 meters from the United States Geological Survey (USGS). Due to the unavailability of the elevation of the Karun River bed, the river basin should be initially created in the GIS environment. For this purpose, the river cross sections were used in different parts of Karun River. These cross sections include 80,000 elevation points from the Mollasani to Farsiat station, which include river banks besides the river bed (Fig. 1).

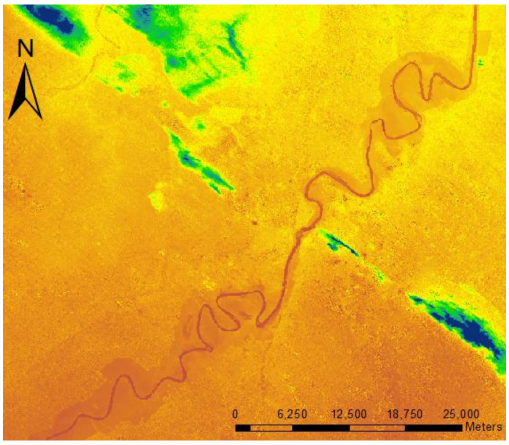


Fig. 1. Dem of Karun River

* Corresponding Author
E-mail addresses: j.zahiri@asnrukh.ac.ir (Javad Zahiri), ashna.mehran@gmail.com (Mehran Ashnavar).

In addition to HEC-RAS, HEC-GeoRAS and GIS have also been used in this study. The HEC-GeoRAS interface contains a simple set of macro tools that can be used to create geometric data and extract information such as cross-sectional information from the DEM using the GIS environment (Ackerman et al., 2010). The process of modeling the Karun River by the HEC-GeoRAS add-on is as follows:

1. Creating a TIN surface from raster data
2. Determine the river route from upstream to downstream using the “Stream Centerline” tool
3. Determine the floodplains by “Bank Lines” tool
4. Using Flow Path layer as a flood plains boundaries identifier
5. Considering 400 cross-sections by the XS Cutlines layer with distances of 300 meters in straight reaches and about 50 meters in bends
6. Using HEC-GeoRAS output to use in HEC-RAS model

3. Results and discussion

Using the Karun DEM and the RAS Mapper interface, output variables such as flow depth and velocity distribution can be displayed and examined at each point of the river cross section. Another benefit of the RAS Mapper user interface is to create an online map layer from the region so that it can display the map of the studied area online on servers like Google Map. Figs. 2 and 3 respectively represent the flow discharge and the water level simulated and measured at Ahwaz station. As seen in these two figures, there is a good fit between modeling and measured data.

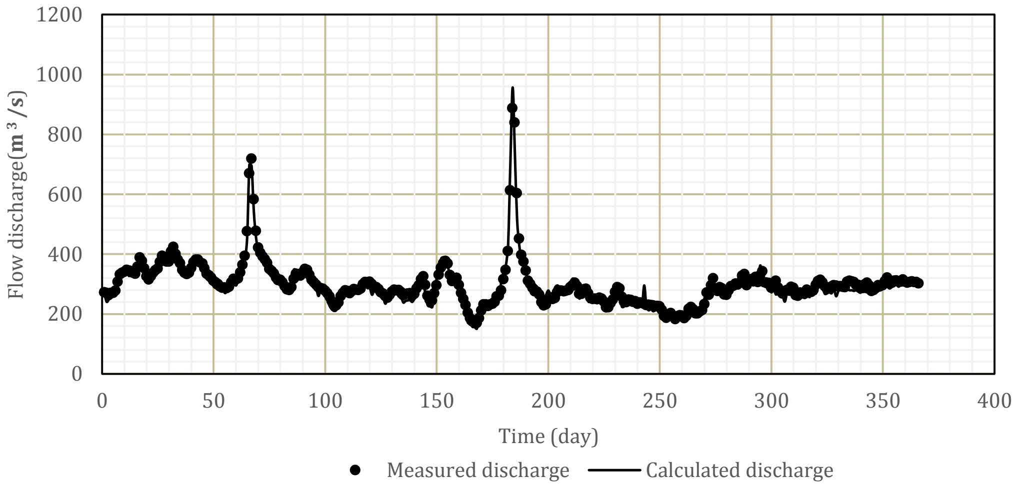


Fig. 2. Comparison of modeling and measured flow discharge in Ahvaz station

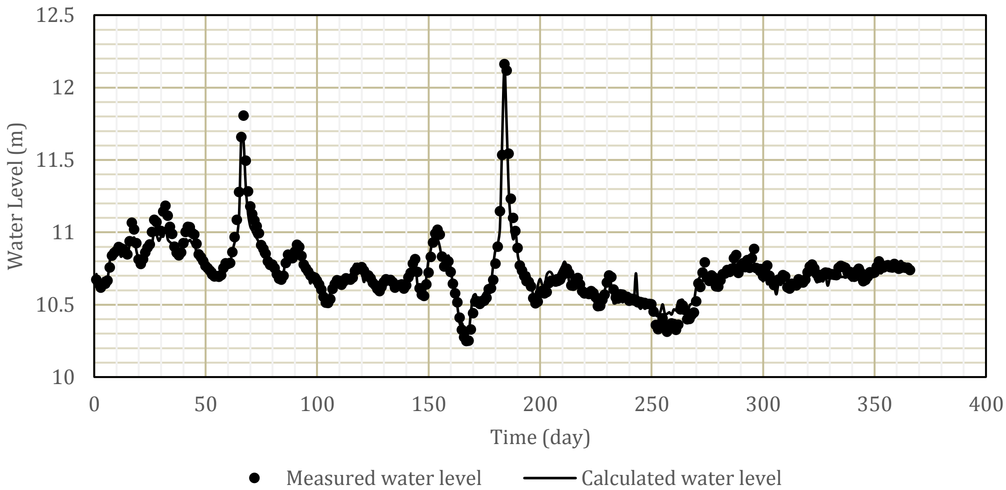


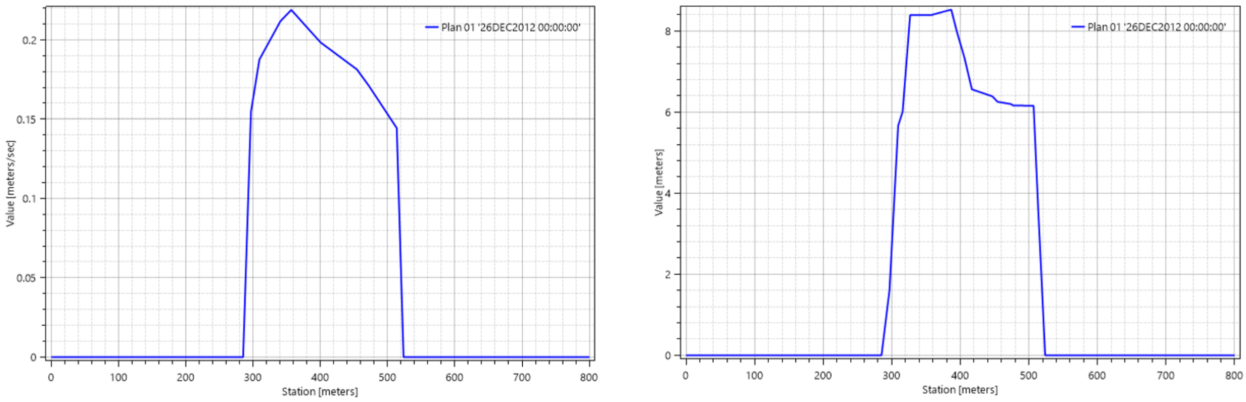
Fig. 3. Comparison of modeling and measured water level in Ahvaz station

The values of R^2, NSE and RMSE are shown for verifying the hydrodynamic model, in Table 1. In this study, the NSE value for flow discharge and water level was calculated to be 0.946 and 0.904, respectively, which indicates the high accuracy of the modeling. Also, RMSE for flow rate and water level were calculated as 18.159 and 0.06 respectively. These values were obtained for flow rate of 123.13 and for water level 302.0, in Zahiri (2007). This comparison shows that the RMSE value for simulation of the discharge and water level decreased by 6 and 5 times, respectively, indicating that the model has simulated hydraulic parameters with high precision.

Table 1. Statistical analysis of hydrodynamic model

Hydraulic parameter	Statistical Parameter		
	R^2	*RMSE*	NSE
Water level	0.934	0.60	0.904
Flow discharge	0.952	18.159	0.946

Without using the RAS Mapper user interface, hydrodynamic models in one-dimensional mode calculate a constant value for flow velocity and depth for each cross section. By using the RAS Mapper interface and the region's elevation model for the entire river course, flow depth and velocity of the river are simulated and well evaluated. In the river bend, the hydraulic parameters are subject to extreme changes relative to the flow in the straight reach, so that the flow depth and velocity in the outer bend is much greater than the inside of the bend. In Fig. 4, the values of velocity distribution and flow depth in the middle of the bend demonstrated. The maximum velocity near the outer bend is more than 0.21 m/s and the inside of the bend is 0.15 m/s.



(a) (b)

Fig. 4. Profile of (a) velocity distribution, (b) water level for mid-bend cross section

4. Conclusions

In this research, due to time consuming of two and three-dimensional models, a one-dimensional HEC-RAS model was used to simulate flow in the Karun River between the Mollasani to Farsiat hydrometric stations. One of the most important weaknesses in one dimensional modeling is the lack of modeling of the velocity distribution along the river, which is especially important in river bends. To overcome this defect, satellite imagery and GIS environment were used to prepare the Karun River digital elevation map. With the elevation digital map and the use of the RAS MAPPER environment, it is possible to simulate the velocity distribution in all parts of the river. Given the velocity distribution, it is possible to discuss the extent of the vulnerability of river banks, more precisely. In addition to velocity distribution, the flow depth was simulated along the river according to the three-dimensional topography. To validate the results of the proposed model, various statistical analysis were used. Nash-Sutcliff coefficient was determined to be more than 0.9 for water level and flow rate at Ahwaz station, which was considered as the control station. This value for Nash-Sutcliff coefficient indicates the high accuracy of this method in simulating flow pattern in the Karun River.

5. References

Ackerman CT, Jensen MR, Brunner GW, “Geospatial capabilities of HEC-RAS for model development and mapping”, 2nd Joint Federal Interagency Conference, Las Vegas, NV, 2010.

Zahiri J, “One-dimensional modeling of sediment transport in Karun River”, MSc Thesis, Chamran University, Ahwaz, Iran, 2007.