Determination of Flood Plain Zoning in Zarigol River Using the Hydraulic Model of HEC-RAS

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ABSTRACT: Several methods have been presented to flood administration and reduction and the results of flood risks until now. One of the employed methods is the Flood Plain Zoning (FPZ) method using hydraulic analysis that is based on a hydraulic model. Hydraulic models can draw the water surface profile in each arbitrary section. At first, the flood period is given; then the water surface level in different cross sections is calculated using the model, subsequently these points over the topographic plan of the zone are compared, to find the flood plain zone; and finally we can make required predictions to flood administration on the risk of flood. The current case study is an interval of Zaringol river in Golestan province in Northern Iran which is 24,210 meters long. Golestan province is the first region in Iran with the most detrimental floods and is always at risk because of its position, so presentation of accurate methods to determination of the accurate plain zone of flood is necessary to prevent the probable risks. To this end, in this paper, the hydraulic model of HEC-RAS to hydraulics calculations and the ArcView software are employed to extract the cross section using topographic plans of river and FPZ in Geographical Information System (GIS) with flood periods: 2, 5, 10, 50 & 100 years and the scale of plans is 1:10000. The zones that were at risk were determined and finally several methods were recommended to prevent the zone reduction and the detriments of flood. This inquiry completely showed that incorporation of the hydraulic model of HEC-RAS and GIS is a useful implement to analyze FPZs.

Keywords: Flood Plain Zoning, Zarigol river, HEC-RAS model, ArcView software.

INTRODUCTION

Water is a vital source for human beings and other creatures, but sometimes this vital factor is the reason of some damages and destructions. Some methods have been presented to flood administration and reduction and the results of flood risks until now. One of the methods is the Flood Plain Zoning (FPZ) method using hydraulic analysis based on a hydraulic model. Hydraulic models can draw the water surface profile in each arbitrary section. Fundamental and scheduled expediencies can be done to prevent the intensity and to control the detrimental floods as a natural problem at the time. So the first step to good management and programming, and taking strategies to encounter this natural danger as well as reduction of its detriments is specification of the sensitive regions and providing flood danger plans.

Recognition of river demeanor and right engineering actions are the permanent worries of water engineers. These factors cause that water engineers contemplate new remedies to management and control of this natural phenomenon with reliance on modern implements such as mathematical methods and Geographical Information System (GIS). But everyone knows that controlling floods is completely impossible and we can to the least reduce these detriments with special contemplations (Arhami, 2002).

One of instances that leads to increasing the flood detriments is using flood plain or the regions next to the rivers because of their suitable situation, therefore most social and economy-related works are in these regions. Hence, FPZ and specification of the zones subject to flood is necessary as one of the administering methods for confrontation with floods.

In recent years implementation of the hydraulic model of HEC-RAS with GIS software has been recommended as a solution to FPZ. For example, Azagra (1999) used the hydraulic model HEC-RAS for FPZ on Wader river in Texas with providing air photos and processing the FPZ plans. Johnson and Strickland (1999) utilized the HEC-RAS model to predict and determine the bounds of suitable zones in 10 kilometers of Youl river in...
the US. There are other studies and inquiries that have been conducted and performed in this field including Tate (1998), Islam and Kimi (2000), and Stephenson (2002).

In sum, the current study aims to specify the zones subject to flood danger in Aliabad city in Golestan province, scrutinize the quantity of zones that have economic worth but are subject to flood detriments in different periods, and create the scrutiny and risk analysis in the future.

MATERIAL AND METHODS

The Study Site
The study site is a zone of Zaringol river flood plain. Its area is 342.82 km\(^2\) located in Golestan province and in eastern latitude of 54/57/10, northern longitude of 36/52/20 and is in the mountainous regions that cover parts of northern Alborz mountains. Figure 1 demonstrates Zaringol hydrographic network. This part according to geographical divisions in Iran is a part of Gloestan-Guilan provinces. Due to some specific characteristics, it is different from other lands like Central Iran and Zagros.

![Figure 1. Zaringol hydrographic network](image1)

Triangulated Irregular Network
Providing Triangulated Irregular Network (TIN) model is one of the applications in ArcView software. In these models, the features are represented like a collection of triangular surfaces that are allied together. Whatever the scale be better, the TIN layer will appear more actual. Figure 2 demonstrates our confines of TIN.

![Figure 2. Zaringol river TIN model](image2)

The Hydraulic Model
The US. Army Corps of Engineers’ River Analysis System (HEC-RAS) is a software that allows us to perform one-dimensional steady and unsteady flow river hydraulics calculations. HEC-RAS is an integrated system of software, designed for interactive use in a multi-user network environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics and reporting facilities.

The HEC-RAS system will ultimately contain three one-dimensional hydraulic analysis components for: (1) steady flow water surface profile computations; (2) unsteady flow simulation; and (3) movable boundary sediment transport computations. A key element is that all three components will use a common geometric data representation and common geometric and hydraulic computation routines. In addition to the three hydraulic
analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed (US Army Corps of Engineers, 2000).

**Extracting Cross Section Parameters Using HEC-GeoRAS**

To extract the cross section parameters and morphological simulation, we must define in ArcView software using HEC-GeoRAS a series of points, lines and polygon layers to the extension of the geometric data to illustrate the canal centerline, stream centerline, left and right over banks in order to their entry into the HEC-RAS model. Figure 3 demonstrates how we can extract the cross section parameters using HEC-GeoRAS.

Figure 3. How we can extract channel morphology using TIN

After these pre-processing stages using HEC-GeoRAS, the 3D information that clarifies the shape, height and position and the overall cross section traits of channel are extracted and entered into the HEC-RAS model.

**Cross Sections**

The position, situation and width of sections are introduced in cross layers. We have to consider the following factors (Iran Water Resources Management Company, 2005) in order to draw the cross sections lines:

- Every cross section must be drawn from the left-side bank of the river to right-side.
- The cross section line must be a cut stream line on left and right over banks.
- The cross section line must be lined to stream line.
- The cross section lines should not cut each other.

In this paper the length of the interval is almost 24, 210 m that is defined as 28 cross sections in this interval to introduce the geometry of the river to the HEC-RAS model. The distances between the sections are various. If there are curves in the stream line, the distances between sections have been shortened. The determination of the sections starts from the left side of the river and ends in the right side.

**Maning's Coefficient**

To find the Maning's coefficient, we took the boundary condition of Shirinabad station and run the model, the observed value was compared with calculated value in Zaringol station, and by trial and error and estimating these two numbers, \( n \) was altered and elected as 0.029 for the main channel. We have to note that because of walls irregularity and vegetation, the roughness of banks had increased, so using air photos and also Chow's table, the roughness coefficient of flood plains was elected as 0.032 and introduced to the model (Energy Ministry of Iran, 1997).

**Maximum Instant and Daily Discharge in Various Returning Periods**

To define the best static distribution according to Gharib and Roustaei (2008), the empirical curve was compared with theoretic curve and which was the one that had the most corresponding between the theoretic and empirical axis, elected as the best distribution coefficient. The results of this analysis are presented in table 1.

<table>
<thead>
<tr>
<th>T (Year)</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instant maximum discharge</td>
<td>22</td>
<td>46.92</td>
<td>71.73</td>
<td>158.53</td>
<td>212.90</td>
</tr>
<tr>
<td>Daily maximum discharge</td>
<td>18.28</td>
<td>35.88</td>
<td>51.57</td>
<td>99.06</td>
<td>125.36</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

Simulation of the Steady Flow in the HEC-RAS Model

All the parameters and data were given to the model to show the river network and all hydraulic structures. The water surface profiles and river hydraulic in all of cross sections were simulated and some information such as water surface profile, distribution of water velocity and critical depth in species of regimes were obtained (See Figure 4).

Flood Plain Zone and its Area for Various Periods

After entering the data of the flood level for various periods and other information to the ArcView software, the zone of flood plain was extracted. Although creating water surface TIN layer due to different returning periods is another result of this method. With determination of the confidence in this layer to the 3D layer of the zone, we can extract the water depth from every point. Hence we can obtain the flood plain zone of river bed for various periods and we can use our zones against flood safely, with confidence to the provided guidelines of FPZ and determination of flood way and flood fringe. Figure 5 demonstrates this flood plain zone for the period of 100 years.
And other areas for various periods are in Table 2.

<table>
<thead>
<tr>
<th>T (Year)</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>50</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood plain area (Hec)</td>
<td>36.44</td>
<td>43.28</td>
<td>48.51</td>
<td>67.21</td>
<td>82.14</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

The findings of the present study revealed that the results of the ArcView software and the HEC-RAS model have good correlations and they are proper and operative methods to use in future programming such as flood insurance, recreation constructions and so forth. Because of the extent of the zone of our case study, occurrence of the substantial problems in the time of flood in upper periods is probable. Hence ordering the Zaringol river (structural and non-structural methods) is necessary in the time of flood to reduce the detriments to the least. In high period floods, albeit the cross sections are extent, but because of the little slope of river, the water level is upper than the cross sections and the flood surrounding the nearby plains. Therefore, using longitude embankment in the stream line (residential and municipal regions) is necessary for the retention of submersion of the banks and also whereas Zaringol bed river is subject to erosion and sedimentation in the bed, as time goes on, the river conveyance capacity reduces and so in intense floods, the water level comes up and nearby regions will be subject to flood danger. To dispel this problem, we can use dredging operations and sediment removing from the river bed (Mosaedi, 2002).

**Suggestions**

Currently, owing to the promotion of the sciences and emerging hydraulic models such as the HEC-RAS model that can determine the flood plain zone precisely as well the significance the Zaringol river, it is suggested in order to complement the results of this study, further studies are required to be conducted in other intervals of Zaringol river and the river flood comprehensive management projection at present. Similar studies are called for significant rivers of Iran in residential and urban zones.

**REFERENCES**


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