Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 3 [7] June 2014: 102-107
©2014 Academy for Environment and Life Sciences, India
Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.533
Universal Impact Factor 0.9804

ORIGINAL ARTICLE

Determining Flood Zones Using HEC-RAS Model (Case study: Gale Hassan River situated in Atrak watershed)

[1]**Mirmahdi Soleymani,** [2] **Hossein Sedghi,** [3] **Amir Khosrojerdi ,** [4]**Fereydoon Kaveh,** [5]**Hossein Babazadeh**
[1]Department of Water Engineering, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran
[2]Department of Water Engineering, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran
Email: hsedgh@yahoo.com
[3]Department of Water Engineering, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran
[4]Department of Water Engineering, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran
[5]Department of Water Engineering, College of Agriculture and Natural Resources, Science and Research Branch, Islamic Azad University, Tehran, Iran

ABSTRACT
Flood zone knowledge is of great importance in river management and coastal safety. Due to this, to prevent flood risks, to organize and improve rivers and to specify the existing facilities in the vicinity of rivers, it is required to determine the flood zones with different return periods. The aim of this study is to determine the flood zone for 15 kilometers of Ghale Hassan River using HEC RAS model and HEC-Geo RAS. For flood mapping, 25-yearflood discharge in three main areas of the river in terms of existing subzones were calculated and used. 25-year discharges of Ghale Hassan River, upstream to downstream in three areas are 89, 109 and 169 cubic meters per second, respectively. The results showed that the average wetted cross-section (25-year flood zone) in Ghale Hassan River was 85 meters, where the maximum and minimum sections were 378 and 22 meters, respectively.
Keywords*: Gale Hassan River, HEC-RAS, Flood Zones*

Received 21.03.2014 **Revised 12.04.2014** **Accepted 04.06.2014**

INTRODUCTION
Flood zone knowledge is of great importance in river management and coastal safety. Due to this, to prevent flood risks, to organize and improve rivers and to specify the existing facilities in the vicinity of rivers, it is required to determine the flood zones with different return periods. Level processor models have been developed in the sciences of geology and geomorphology and some developments have been made in this regard [1]. Some of these developments include improved models such as new level processors, new algorithms for determining sediment transport and new methods for determining flood damage. Geographic information systems are effective tools for analysis and determination of flood hazards [2].Following a great flood that causes extensive damages, updated and predictable information about flood is needed to save lives and the property of people, among which GIS can play an important role in achieving these goals [3].The most basic steps in flood plain management are flood control, estimation of flood damage, flood insurance determination, and determination of the exact boundaries of the flood plain or flood mapping; and these results may not be achieved but through hydraulic analysis. With increased accessibility to digital information and the effectiveness of computer-based analysis, geographic information systems, GIS, has played an important role in hydrologic and hydraulic modeling. The main advantage of using GIS in modeling is the considerable potential for extracting digital information from a digital elevation model, DEM. In this study, the hydraulic model, HEC-RAS, HEC-Geo

RAS and Arc-GIS have been used to study and evaluate flood flows and flood zone mapping in a range of Atrak River.

Johnson et al. [4] used HEC-RAS model to predict and determine the desired land boundaries, 10 km along the Wyoming River - Gary Bull in America. Using the model, the water surface profile of the river was plotted [4].Using HEC-RAS software, David and Smith [5], evaluated the hydraulic behavior of the flood . David, et al. [6] studying flood for a period of 5 years in the United States, prepared flood zone maps. Knebl *et al*. [7] using the hydrological model, HEC-HMS, and hydraulic model, HEC-RAS, and radar precipitation estimate (NEXRAD) in the basin of San Antonio, Central Texas, United States suggested logic model for flood, and compared the model with the summer 2002 flood. Results showed the model efficiency in regional-scale flood forecasting [7].

Napradin *et al.* [8] made flood hazard mapping for small watersheds near Baya Sea in Astore valley. For this purpose combination of Wet Spa and Hec-Ras was used.

MODEL DESCRIPTION

In the present study, unsteady, gradually varied flow simulation model *i.e.* HEC-RAS, which is dependent on finite difference solutions of the Saint-Venant equations (Equations (1)-(2)), has been used to simulate the flood in the GaleHassan River.

$$\frac{\partial A}{\partial t}+\frac{\partial Q}{\partial x}=0 \qquad (1)$$

$$\frac{\partial Q}{\partial t}+\frac{\partial\left(Q^2/A\right)}{\partial x}+gA\frac{\partial H}{\partial x}+gA\left(S_0-S_f\right)=0 \qquad (2)$$

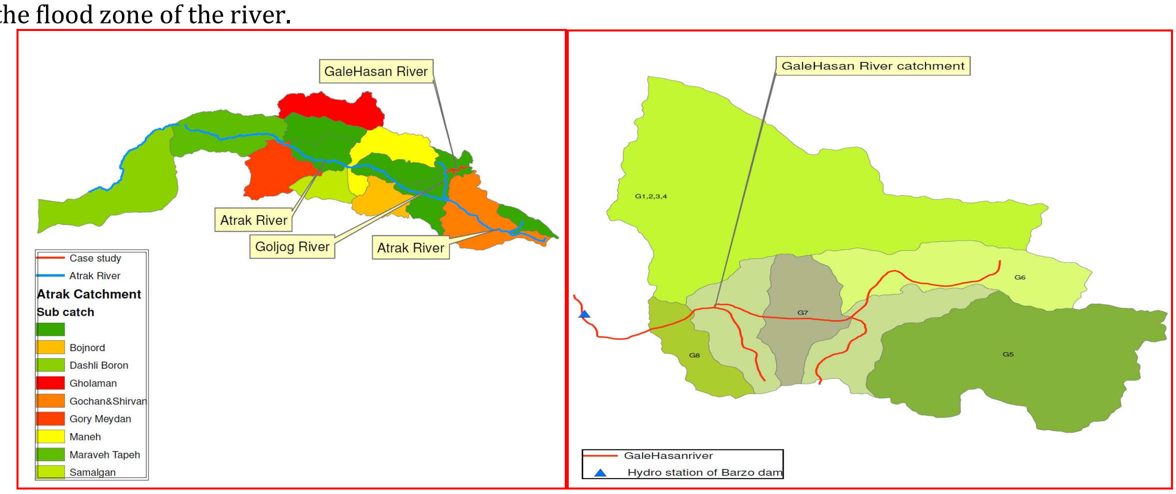
here A = cross-sectional area normal to the flow; Q = discharge; g = acceleration due to gravity; H = elevation of the water surface above a specified datum, also called stage; So = bed slope; Sf = energy slope; t = temporal coordinate and x = longitudinal coordinate. Equations (1) and (2) are solved using the well known four-point implicit box finite difference scheme [9]. This numerical scheme has been shown to be completely non-dissipative but marginally stable when run in a semi-implicit form, which corresponds to weighting factor (θ) of 0.6 for the unsteady flow simulation. In HEC-RAS, a default θ is 1, however, it allows the users to specify any value between 0.6 to 1. The box finite difference scheme is limited to its ability to handle transitions between subcritical and supercritical flow, since a different solution algorithm is required for different flow conditions. The said limitation is overcome in HEC-RAS by employing a mixed-flow routine to patch solution in sub reaches..

LOCATION OF THE STUDY RANGE

Atrak watershed is located in the northeast of Khorasan province and at the border of three countries, Iran, Turkmenistan and Afghanistan. Atrak is the most important river of the watershed.

Gale Hassan River is one of the branches of Atrak River that originates from Kope Dagh Mountains located at the north of Shirvan,beginning from the running water of Pirdanlu village and extends about 15 km toward the south-west to Barzoodam site. Gale Hassan River is permanent at Sarab, and the general direction of the river is east-west. Location of Study range starts from zoortanloo village 2 km upstream (coordinates 4163564 and 599280) and extended toward 15 km downstream the river near the koorkanloo village (coordinates 4164295 and 588485).

There are some gardens and there is a access road of upstream villages in the vicinity of Gale Hassan River and in the case of flood, damages will be done to the region that indicates the necessity to determine the flood zone of the river.



Study zone of the river covers an area of 310 square kilometers, which is divided into 6 subzones and 2 middle zones (subzones of G1, G 2, G 3, G 4, G 5 and G6 and middle zones of 7G and 8G).
G5 subzone is as the entrance zone, which has an area of 5/76 square kilometers and an average bed slope of about 7 percent. G6 Subzone has an area of 33/5 square kilometers and a slope of 6 percent and G1, G 2, G 3, G 4 subzones have an area of 125 square kilometers and the average slope of 7% .
Barzou rain gauge station in rural area of Barzou was selected as the reference station for the study zones and a 30-year reference period was chosen from 1354-55 to 1383-84.
The monthly distribution of precipitation for each study unit in river range is presented below in Table (1).

Parameter	Study unit	October	November	December	January	February	March	April	May	June	July	august	September	Per year
precipitation (mm)	G_1	14.4	34	36	29.6	38.5	53.1	57.2	52.5	19.3	1.5	0.6	2.2	332
	G_2	14.7	34.7	36.8	30.2	39.3	54.2	58.4	53.6	19.7	1.5	0.6	2.3	339
	G_3	15.1	36.7	39	32	41.6	57.4	61.9	56.7	20.8	1.5	0.5	2.4	358
	G_4	14.8	32.5	34.5	28.4	36.9	50.9	54	50.2	18.4	1.4	0.5	2.2	38
	G_5	15.5	36.5	38.7	31.8	41.4	57.1	61.5	56.4	20.7	1.6	0.5	2.4	356
	G_6	15.8	37.3	39.6	32.6	42.3	58.4	62.9	57.7	21.2	1.6	0.5	2.4	364
	G_8	15.1	35.6	37.8	31	40.4	5.7	60	55	20.2	1.5	0.6	2.3	348

Table.1 the monthly distribution of *precipitation for* study units of Gale Hassan River

To calculate the running water of study units of Gale Hassan River, data from Kurkanlou hydrometric station located on Galjag River has been used.
To calculate the flood discharge which is one of the most important parameters, first, the flood peak discharge at Barzou hydrometric station was analyzed and extended to the study units, and then for scrutiny, it was calculated using regional analysis method and experimental methods calibrated with the flood zone. Finally, with regard to the proximity of the Kurkanlou hydrometric station and the range, numbers obtained at the station were used to estimate flood. (Table 2)

Table.2 The amount of flood at study zones (at the output) - cubic meters per second

Name	Return period (year)					
	2	5	10	25	50	100
G_1	4	9	13	18	22	26
G_2	9	18	25	35	43	50
G_3	10	21	29	41	50	58
G_4	6	13	18	25	30	35
G_5	14	30	42	59	72	84
G_6	8	16	23	32	39	45
$\bar{G}_7$	12	26	36	51	62	72
$\bar{G}_8$	4	8	11	15	19	22
G_0	41	85	121	169	205	240
$\bar{G}_{04}$	21	43	61	86	104	122
$\bar{G}_{06}$	22	45	64	89	108	126
$\bar{G}_{07}$	27	55	78	109	132	155

Flow determination
flow regimes of the rivers are changing based on two dimensionless Reynolds (Re) and Froude (Fr) numbers, the dimensionless numbers are defined as follows:

$$Fr = \frac{V}{\sqrt{gD}} \quad R_e \frac{VR}{\gamma}$$

V= Mean flow velocity in meter per second
R = Hydraulic radius in meter
γ =Kinematic viscosity of water in square meter per second
D = Equivalent hydraulicdepth in meter,
A = water flow area in square meter
T = water level width at the desired section in meter
Four types of flow are defined by the above equations
there are usually supercritical turbulent regime in steeper rivers and turbulent subcritical regime, in less steeper rivers. According to the overall slope of the river, which is about 5.1 percent, there is a supercritical turbulent flow regime.

Energy loss

One of the most important factors required to solve the energy equation in HEC-RAS software is the calculation of energy loss, the different types of energy loss can be included in the software are classified as the following categories.
-Loss due to shape, material, vegetation and… channel bed (roughness coefficient)
-Loss due to section contraction orexpansion
-Loss due to the bridge piers of closed ducts and generaly transversal structures.

Roughness coefficient

Since the roughness is one of the main parameters of energy loss in canals and rivers and plays an effective role in water alignment and flow rate in each section, the appropriate roughness coefficient determination, which represents the river real condition is of great importance. Basically, roughness coefficient is expressed in three forms: Manning's coefficient, Chezy coefficient and Darcy Weisbach coefficient and generally, is expressed in the form of Manning's coefficient in the studies of rivers and canals. Factors effecting Manning's coefficients are:
•surface roughness, due to grain-size and bed particle size
•bed shape, due to sediment loads and dunes
•vegetation
•vertical barriers to flow
•irregularities of channel and flood plain
• channel direction and presence of the maze
•Sedimentation and river digging
•water depth.
In general, given the tests, photographs and visits that have been made the riverbed grain-size, along the range, was approximately constant and fine. According to the empirical formula and river bed grain-size, the average roughness coefficient of the river bed is calculated 0.027.

Loss coefficients due to contraction or expansion within the sections

Turbulence occurs in the flow of the river when the dimensions of two sequential sections change.
This turbulence leads to energy dissipation, whose amount is generally higher in the case of expansion in compared to the case of contraction.The amounts of Energy loss coefficient resulting from changes in the size of the sections used in HEC-RAS software, is presented in the table below:

Table 3: Coefficient of energy loss due to contraction and expansion in sections

loss coefficient of contraction (cc)	loss coefficient of expansion (cc)	Section changes
0	0	unchanged
0.1	0.3	Normal
0.3	0.5	big
0.6	0.8	sudden

In the range of Gale Hassan, Normal changes with expansion loss coefficient of 3.0 and the contraction loss coefficient of 1.0 were used.

Boundary conditions

To predict the characteristics of the flow in a portion of the river, boundary conditions consistent with the reality are required.
Determining whether the flow regime is subcritical, supercritical, or mixed, leads to the need for a boundary condition at upstream, downstream, or both.
•stage discharge curve
•critical depth

•uniform flow

In the boundary conditions upstream and downstream, the normal slopes of the upstream and downstream the river were used and flowwas simulated in mixed supercritical and subcritical mode.

CONCLUSION

Determine the river boundaries and bed, including a 25-year pervasive flood zone. Riverbed is the land that is held by government and the manipulation is not allowed. Gale Hassan River is a permanent, young and mountainous river.

Since it is a mountainous area and agricultural lands are limited, lands of the riverside have changed into gardens and horticulture is one of main jobs of the area. Due to the availability to the villages along the river and the construction of garden houses, access road can be seen all along the river.

Geologically, the study area of the river is related to the Cretaceous period and includes Tirgan, Sarcheshme, and Sanganeh formations.

Some parts of the river are exposed to erosion and floods have causedthe erosion of lateral walls of the river and widening of the river. In some parts, villagers have built stone walls to protect their gardens against erosion. Riverbed grain-size is fine and unchanged all along. Because of the proximity of the gardens and facilities to the river and sometimes within bed of the river, floods can cause damage. For flood mapping, 25-year flood discharge in three main areas of the river in terms of existing subzones were calculated and used. 25-year discharges of Ghale Hassan River, upstream to downstream in three areas are 89, 109 and 169 cubic meters per second, respectively.

The average river slope was 5.1%, the average flood velocity was 3.5 meters per second and Froude number was approximately more than 1 all along the river, which indicates a supercritical flow. The average water depth and the average bed width were 1 m and 40 m, respectively. The average wetted cross-section (25-year flood zone) in Ghale Hassan River was 85 meters, where the maximum and minimum sections were 378 and 22 meters, respectively.

SUGGESTIONS

The mountainous and recreational area of Gale Hassan River, and the limited lands for agriculture and horticulture, has led to manipulate the river bed for the purposes of agriculture, horticulture and construction of garden houses. To prevent flood damage and protect the boundaries and the bed of Gale Hassan River, the following is recommended :

1. Boundaries and bed of the river are determined so farmers will be aware of unauthorized areas and they will not work there permanently. So it is recommended that authorized activities should be taught to the owners.
2. Reorganization plan should be implemented for Gale Hassan River in order to prevent erosion and changes in the river route and to create a sustainable bed. For this purpose, due to the lack of appropriate lands, in order to prevent flood damage and soil erosion, through various activities such as planting trees and building walls, erosion can be prevented.

REFERENCES

1. Clevis, Q., Tucker, G, Lancaster, S., Desitter, A., Gasparini, N. and Lock, G. (2006). "A simple algorithm forthe mapping of TIN data onto astatic grid: Applied to the stratigraphic simulation of river meander deposits." Computers & Geosciences ,Vol.32,,No.6, PP. 749-766.
2. Sinnakaudan, S.K., Ghani, A.A., Ahmad, M.S.S., Zakaria, N.A. (2003). Flood Risk Mapping for Pari Riverincorporating sediment transport. Journal of Environmental Modeling and Software. Vol.18,No.2, PP. 119-130.
3. Colby, J. D., Mulcahy, K. A., and Wang, Y. (2000), "Modeling flooding extent from Hurricane Floyd in thecoastal plains of North Carolina", Environmental Hazard, Vol.2,PP. 157-168.
4. Jonson, S. K. and J. O. Dominique. 1988. Extracting topographic structure from digital elevation data for Geographic Information Systems analysis. Photogrammetric Engineering and Remote Sensing. 54(11). PP. 1593-1600.
5. David, A., and A. Smith, (2000). HEC-RAS 2.2 for backwater and Scour analysis-phase one, University of Kansas. Department of Civil and Environmental Engineering, University of Kansas Lawrence, Kansas, 88P.
6. David, L. K., M. C. Mastin., and T. D. Olsen, (2002) Fifty-year flood inundation maps for catacamas. Honduras, U.S. Department of the Interior U.S. Geological Survey, 9P.
7. Knebl, M.R., Yang, Z.L., Hutchison, K., Maidment, D.R. 2005. Regional Scale Flood Modeling using (NEXRAD). Rainfall.GIS, and HEC-HMS/RAS:A Case study for the San Antonio River Basin Summer 2002 storm Event, Journal of Environment Management,75:325-336.
8. Napradean, I and Chira, R. 2006. The hydrological modeling of the Usturoi Valley - Using two modeling programs - WetSpa And HecRas. Carpathian Journal Of Earth And Environmental Sciences.v1.issn (1842-4090.53-62).
9. US Army Corps of Engineers, (2002). USACE "HEC-RAS, User Manual," Washington, DC.

10. USACE, (2009). HEC-GeoRAS, GIS Tools for Support of HECRAS using ArcGIS. User's Manual, Version 4.2, U.S. Army Corps of Engineers, Davis, California, 246 p.

Citation of This Article

Mirmahdi S, Hossein S, Amir Khosrojerdi, Fereydoon K, Hossein B. Determining Flood Zones Using HEC-RAS Model (Case study: Gale Hassan River situated in Atrak watershed). Bull. Env. Pharmacol. Life Sci., Vol 3 [7] June 2014: 102-107