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Flood risk assessment in Ardabil valley Shirvan aquiferous zone

Tahereh Zamani*

MA in Watershed Management, Islamic Azad University of Torbat-e Jam

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ABSTRACT

Many people's lives and property are threatened by annually around the world. Thus, it is necessary to identify areas with flood risk in order to apply systematic management in urban auriferous zones. First, topographic maps and Si valley Shirvan River aquiferous land use was prepared and river basin border was drawn based on these maps, then the river divided to 3 sub-basins and these sub-basins divided to 5 hydrological unit and these units divided to 4 sub- hydrological units, and flood hydrographs were calculated in return periods of 2, 5, 10, 25, 50, 100, respectively. Within the area of S1-1-1 with a length of 3.5 km in Si valley Shirvan River, geometric information of river was obtained. In the next stage, by introduction of flow characteristics and river geometric information and each profile coefficient in HEC_RAS software, water level profile in different return periods was calculated and average level and depth of flood for risk areas was determined. Finally, using flood damages functions, damages were calculated and level-damage curve was drawn. The results showed that damage increase trend of floods with a return period of more than 25 years and average flooding depth greater than 0.52 m is more intense.

INTRODUCTION

Research and executive units in the field of hydrology and water engineering are aquirefous zones. Hydrological studies provide basic information to design hydraulic structures. This report is hydrological studies of Si valley aquiferous zone. The studied area is located in Ardabil. This area has formed upstream aquiferous and flooding zone. Aquiferous zone, which is limited by coalescence of a river or lake surrounding mountains ridges, is an area that directs surface waters to considered river or lake. Today, in agricultural and natural resources studies, aquiferous basins are used as planning units. Physical characteristics of basin affect runoff coefficient, intensity, flood discharge and water balance significantly. For example, north and south directions are different in terms of snow melting time and steep areas affect runoff increase significantly. Different physical methods improvement for flood control increase safety against flood. However, safety level in large rivers is not satisfactory, despite flood control operations. Therefore, it is necessary to implement flood control operations more reasonable with non-physical methods and using new information systems. Meanwhile, Flood risk zoning map is of great importance. It is necessary to identify flood areas to provide administrative approaches. Flood management is a complex topic due to various sources and urban development in floodplains. Hence, development of such areas should be based on comprehensive and accurate view of available resources and related factors.

Morphological features

Based on physiographic studies, studied area called Si valley Shirvan, with an area of 14666.1 hectares is located in the region to east longitude and north latitude. Its circumference is 94.8 km, the lowest and highest altitude in the region is 938.1 and 4781.3 meters. Politically, this area is located in Ardabil province, Meshkinshar city, Eastern Meshkin, Gharehsou and Lahout villages. Figure 1 indicates political situation of basin. In terms of geographical location, this basin is originated from Sabalan mountain, which is located on it northern domain. In other words, the most natural effect is Sabalan Mountain, which is located southern end of basin. Northern border of Si valley Shirvan basin is limited to Gharehsou River. Therefore, this basin is not independent, but it has multiple outputs. Among many waterways to Gharehsou River in studied area, there are 3 main waterways that comprise three independent sub-basins. The waterways between these three sub-basins developed units 1S-int to 4S-int. In figure 1, regional basic map is shown and in table 1 some regional morphometric characteristics are shown. Residential areas within the area include: Lahroud, Jalayer, Dadebyglou, Kanglou, Ghareh Qāyeh. Shabyl tourist area is located in studied region and attracts many tourists each year because of mineral water. In addition, Ghotoursouie mineral water is located near border of basin.

**Corresponding author:* Tahereh.Zamani@gmail.com
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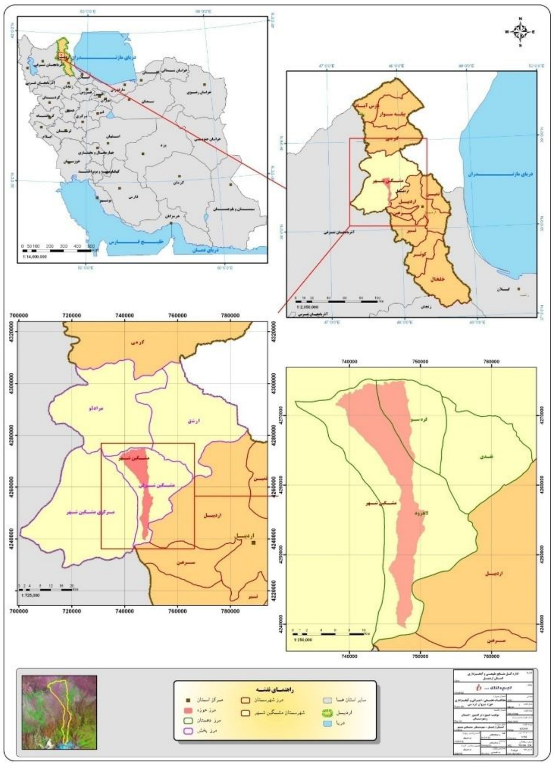


Figure 1. Political location of basin

Table 1. Physiographic characteristics of each watershed hydrologic units in Si valley Shirvan aquiferous basin

Center of gravity Longitude	Center of gravity latitude	Compactness coefficient (C)	Concentration time (h)	Basin slope %	Medium Height (m)	Maximum Height(m)	Minimum Height (m)	area (hectare)	Basin No.	No.
38° 28' 24/49" N	47° 49' 12/54" E	2/21	3/03	16/5	1632/0	4781/3	938/1	14666/13	S	1
38° 23' 40/11" N	47° 49' 49/96" E	2/88	3/04	29/1	2262/4	4781/3	944/0	6443/42	S1	2
38° 31' 6/80" N	47° 48' 44/79" E	1/83	2/03	6/9	1202/9	1591/0	957/2	2512/73	S2	3
38° 31' 7/82" N	47° 50' 22/72" E	2/13	1/97	9/8	1234/5	1752/4	965/9	2266/18	S3	4
38° 32' 32/63" N	47° 45' 24/91" E	2/04	-	3/9	1042/7	1159/7	938/1	509/67	S-int1	5
38° 33' 17/99" N	47° 46' 37/49" E	1/93	-	3/3	1027/3	1246/7	944/2	1421/81	S-int2	6
38° 33' 55/87" N	47° 48' 40/23" E	1/69	-	6/2	1020/0	1144/9	957/6	980/49	S-int3	7
38° 34' 13/52" N	47° 50' 22/53" E	1/96	-	4/4	1027/6	1127/7	960/4	531/83	S-int4	8
38° 22' 50/96" N	47° 50' 10/93" E	2/56	2/54	31/4	2374/0	4781/3	1116/8	5898/29	S1-1	9
38° 32' 31/79" N	47° 46' 2/61" E	2/39	-	3/9	1055/0	1187/4	944/0	545/15	S1-int	10
38° 30' 51/07" N	47° 49' 24/29" E	1/66	0/76	9/4	1220/5	1417/9	1091/0	543/52	S2-1	11
38° 29' 39/93" N	47° 49' 24/59" E	2/12	1/2	9/0	1340/3	1591/0	1096/9	660/73	S2-2	12
38° 30' 19/95" N	47° 48' 22/09" E	1/64	0/99	5/8	1237/7	1400/0	1105/7	541/06	S2-3	13
38° 33' 5/78" N	47° 47' 58/53" E	1/89	-	4/3	1047/7	1140/0	957/2	767/41	S2-int	14
38° 29' 37/95" N	47° 50' 41/42" E	1/78	1/23	13/3	1363/5	1752/4	1110/7	1244/61	S3-1	15
38° 32' 57/31" N	47° 49' 59/94" E	1/94	-	5/6	1077/4	1260/0	965/9	1021/57	S3-int	16
38° 21' 34/21" N	47° 50' 25/38" E	2/55	2/04	35/6	2601/9	4781/3	1390/5	4067/71	S1-1-1	17
38° 24' 38/64" N	47° 50' 3/66" E	2/27	1/63	26/4	2019/2	2702/8	1387/8	1457/36	S1-1-2	18
38° 29' 47/02" N	47° 48' 1/55" E	2/43	-	5/3	1276/2	1489/4	1116/8	373/22	S1-1-int	19
38° 28' 42/67" N	47° 50' 1/52" E	1/43	0/51	10/4	1449/6	1591/0	1333/0	269/60	S2-2-1	20
38° 30' 19/39" N	47° 48' 59/13" E	2/17	-	8/0	1264/7	1434/4	1096/9	391/14	S2-2-int	21
38° 28' 43.09" N	47° 50' 53.00" E			16/4	1464/7	1752/4	1214/3	662/63	S3-1-1	22
38° 30' 40/40" N	47° 50' 28/22" E	1/72	-	9/8	1248/4	1474/0	1110/7	581/98	S3-1-int	23
38° 19' 38/42" N	47° 50' 1/39" E	1/69	0/98	35/9	2969/2	4781/3	2074/1	2559/31	S1-1-1-1	24
38° 24' 50/67" N	47° 51' 6/14" E	2/42	-	35/1	1978/6	2471/6	1390/5	1508/40	S1-1-1-int	25

Methodology

In this study, for hydrological analysis of zone, hydrometric stations data and statistics are used. Statistical period is from 1974-75 to 2008-9. After completing statistical errors in selected statistical period, homogeneity of Statistics was studied using doubled mass method. Hydrological parameters were evaluated in annual and monthly scales: in this study, different softwares are used. In basin modeling and hydrological modeling, HEC-RAS and HEC-GeoRAS are used to analyze maps and spatial data. Data and statistics of hydrometric stations including daily, monthly and annual discharge and maximum daily discharge were collected and analyzed from relevant organizations including Ardebil Regional Water organization and Department of Energy (water resources management). In this study, data and statistics of surrounding stations are evaluated and in terms of data adequacy, stations with statistics less than 10 years were excluded. The stations characteristics are presented in table 2. Common statistical period has been considered according to meteorological studies (1974-75 to 2008-9). Before data analysis, it is necessary to ensure its quality and statistical series completeness. Without proper evaluation of data, reliable results will not be achieved with complex statistical analysis. Although, standard reading and hydrometric data registration reduces error, but usually initial data need to control or modification. In addition, drastic changes in regional climates are followed by such mistakes and lead to data heterogeneity. There are different methods to control statistics quality; one of these methods is doubled mass curve test. Homogeneity of data means that data related to a random statistical population have a certain trend. In order to evaluate homogeneity of data, the usual doubled mass homogeneity test is used.

Statistical index and data completion period

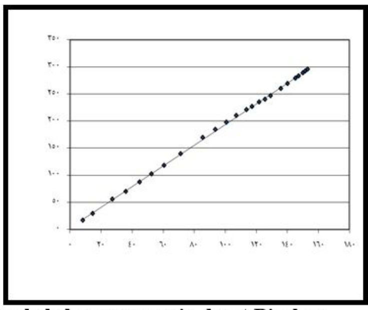
In order to determine statistical index, first, statistical errors of stations with data more than 10 years were rebuilt and extended. Accordingly, based on studied areas of Iran Water Resources Management organization, stations with long data and appropriate statistical data were considered as base station to extend and rebuild annual discharge statistic of other stations, and accordingly, statistical deficiencies and gaps were completed. In order to complete annual discharge statistic, first, statistics extension allowed length (Ne) was determined for each of the stations based on presented criteria in the following equation:

$$Ne = \frac{N}{1+(\frac{N-n}{n-2})(1-r^2)} \quad (1)$$

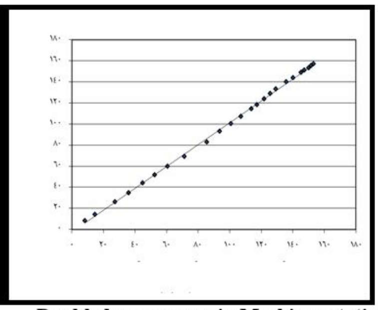
In this equation: Ne is allowed time for statistics extension (year), N is number of registered statistical years in bas station (with long-term statistics) , n is number of registered statistical years in destination (with short-term statistics)and r is correlation coefficient between base station and destination station.

Table 2. Hydrometric stations characteristics in the area

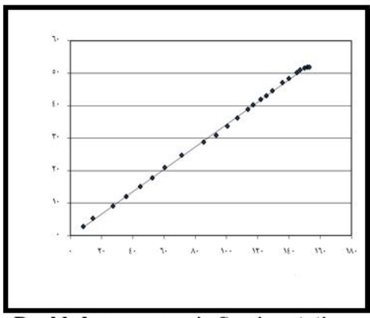
Basin level km^2	Geographical characteristics			Station degree	Equipments			Code	station
	Longitude	Latitude	Height		Eshel	Telephric	Limonograph		
7311	47:31:00	38:32:00	1450	3	+	-	-	19-065	doust Bigelow
98	47:40:00	38:24:00	1150	4	+	-	-	19-063	Soltani bridge
11290	47:58:00	38:72:00	680	1	+	+	+	19-069	Moshiran
480	48:03:00	38:30:00	1180	1	+	+	+	19-873	Arbab Kandi
2035	47:21:00	38:43:00	1215	1	+	+	+	19-067	Tazehkand Ahar
4000	48:15:00	38:23:00	1170	1	+	+	+	19-101	Samian
32	48:46:00	38:42:00	1450	4	+	-	-	19-099	Namin
36	47:09:00	38:12:00	2200	4	+	-	-	19-049	Lai
73	47:67:00	38:00:00	1900	4	+	-	-	31-001	Sahzab
1638	48:22:00	38:19:00	1190	4	+	-	-	19-055	Gilandeh



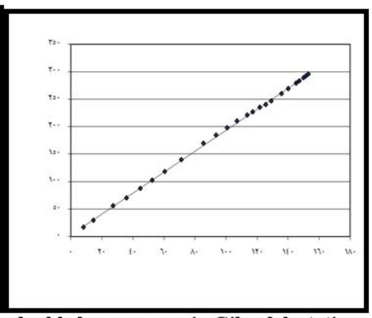
Doubeled mass curve in doust Bigelow



Doubled mass curve in Moshiran station



Doubled mass curve in Samian station

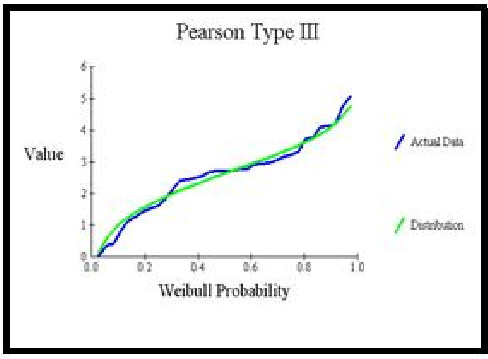


doubled mass curve in Gilandeh station

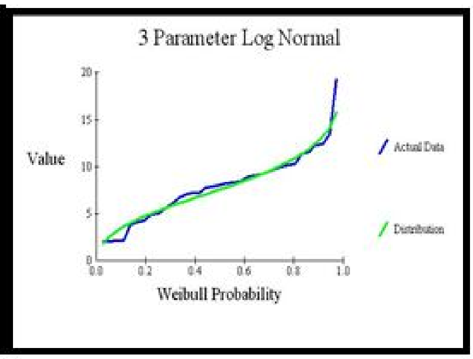
Figure 2. Results of doubled mass test

Maximum daily discharge estimation in hydrometric stations

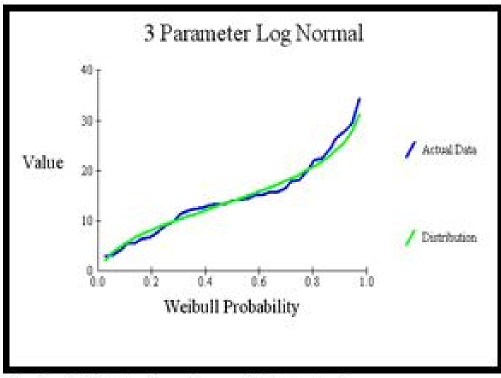
SMADA software is used for annual average discharge. The best statistical distribution between observed and calculated data was determined using Maximum Likelihood and Momentum methods. Figure (3) shows mentioned distributions.



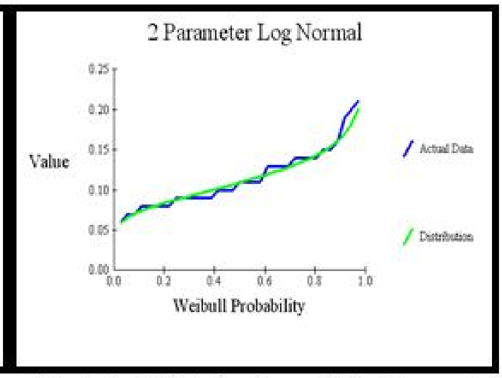
Statistical distribution of doustbiglow station



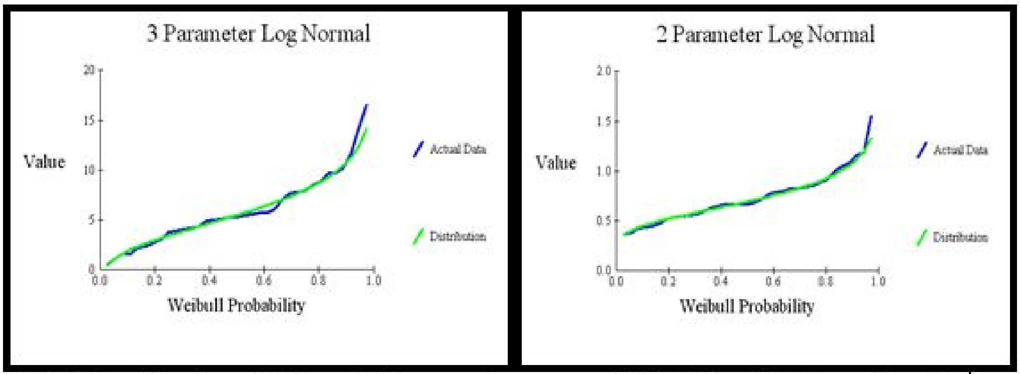
statistical distribution of Gilandeh station



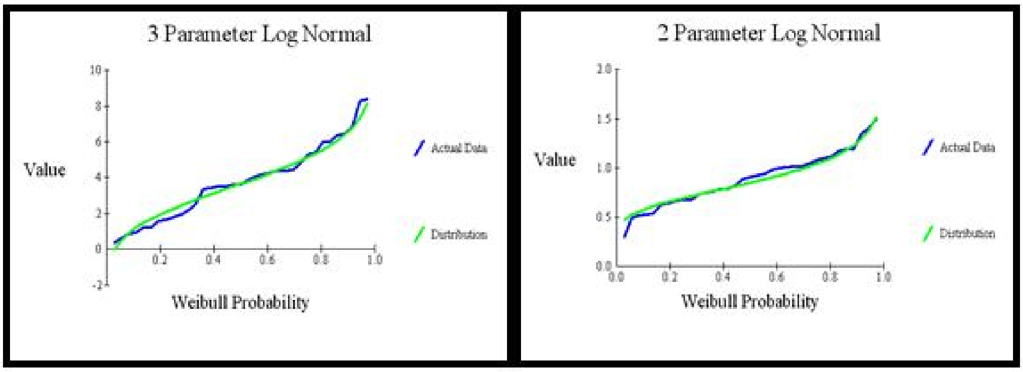
Statistical distribution of lai station



Statistical distribution of Moshiran station



Statistical distribution of Soltan bridge station **statistical distribution of Samian station**



Statistical distribution of Sahzab station **statistical distribution of Tazehkand station**

Figure 3. Statistical distribution results using graphical method in SMADA software

River Flood zoning with HEC-RAS software and general risk assessment

Each surface flow of water, regardless of the cause is considered as flood, if river flow is more than normal flow of river and if water flow exceeds the natural bed and overtakes lowlands, it will be followed with damages. Because of heavy floods in recent decades and damage increase trend, water engineers and other professionals look for a new solution to control and manage these natural phenomena using modern instruments. In recent years due to river engineering objectives development, large scales topographic maps instead of river cross sections, developed significantly to determine flood zone on them in addition to cross sections preparation using these maps.

HEC-RAS results

After all mentioned steps, and transmission of model output to HEC-RAS, this software provides multiple layers including flood zone, which is the most useful layer. It is necessary to transfer hydraulic calculation results in natural conditions to GIS and finally , results of mathematical model HEC-RAS for natural conditions in discharge mode with considered return periods (2,5,10, 25, 50 and 100 years) is located on modified topography (which is actually natural topography of the river) and riverbed is determined.

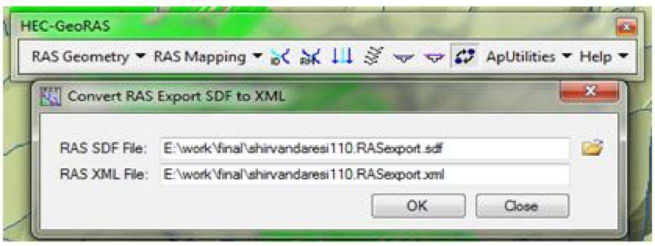


Figure 4. HEC-RAS output file and results information perception

Required files and layers arrangement

After output file preparation with HEC-RAS software, required files are introduced. For this purpose, Import RAS SDF File menu is selected in HEC-Geo RAS. When you select this option, a window appears and required information such as topography model file with TIN format, directory name including generated files and raster data cell size must be included in it.

HEC-RAS software output file reading

With introduction of output file generated by mathematical model HEC-RAS after HEC-Geo RAS , now with RAS Mapping > Import RAS Data command , it is able to read data generated by flow model including river characteristics , cross sections characteristics , water level and flooding width in any profile. By reading this information and transferring them from HEC-RAS mathematical model to ArcGIS, we are able to determine flood zones in next steps.

Flood zone determination

The last step in preparation of zoning maps is RAS Map ing \ Floodplain Delineation command, when HEC-Geo RAS is enabled. With implementation of this command, first, a digital topographic model (DEM) GRID or TIN is provided and then corresponding cells elevation digits DEM will be compared. Obviously, cells with water levels more than ground elevation are considered as a flooded cell and are part of flood zone. Accordingly, all cells that form ground level and water level are compared for floods with considered return periods and flooding zone is determined in studied area.

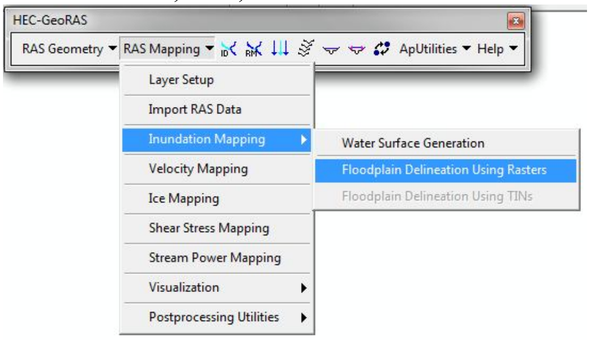


Figure 5. Preparation of flood zoning map

Of flooded level in studied return periods It should be noted that before using these tools, software system must be determined. In the following table, results of this operation can be seen.

Table 5. Flooded level comparison

Flood zone area (M2)	Return period (TR) year
161382	2
162735	5
168778	10
169116	25
169754	50
161382	100

Figure 6. Flood depth comparison

Maximum depth (m)	Minimum depth (m)	Return period (TR) year
1.67	0.01	2
1.93	0.01	5
2.03	0.01	10
2.12	0.01	25
2.14	0.01	50
2.18	0.01	100

Flood damages assessment in different return periods

Based on calculations and as it can be seen in table 6, by flood return period increase, its damages increases, too. It should be noted that mentioned damages are damages potential estimation.

Table 7. Direct damages to residential units

Damage (Billion riyals)	Average damage percentage	Flooding average depth (m)	Return period (year)
3.53	3.14	0.39	5
9.31	8.62	0.44	10
21.2	14.16	0.49	25
34.76	19.21	0.52	50
54.81	22.85	0.54	100

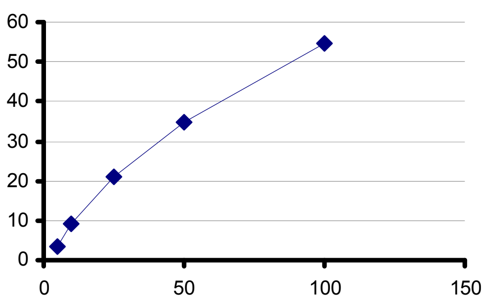


Figure 1. The relationship between flood return period and its damage

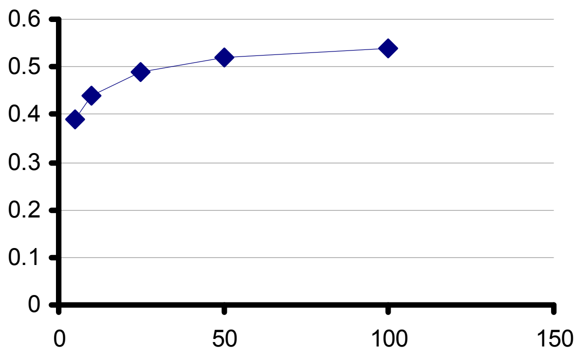


Figure 2. The relationship between average depth of flooding (m) and flood return period

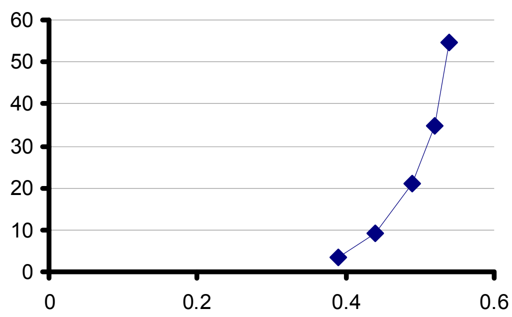


Figure 3. The relationship between flooding average depth (m) and flood damages

Presentation and evaluation of results

According to studied area and obtained results, following points can be cited:

1- With minimum cost, mapping information and required data and using combined application hydraulic software and GIS, we can determine flood zoning and rivers bed easily.

2- When flood occurs, flood zoning can be shown graphically with certain discharges. In addition, if there is no obvious height difference in studied area, and topography of the area is mostly flat, flood zoning is not clear, but in areas with steep topography, graphic display of flood is determined with significant resolution.

3- By comparing the outputs related to flood development in HEC-RAS and GIS, it can be seen that GIS results are more accurate and specific, since in GIS topography is fully defined, while HEC-RAS provides flood development region weaker.

4- If the information in this method is not high enough, possibility of error and inaccessibility to correct answer increases.

5- It is necessary to increase accuracy in mapping by Surveyor consulting firms and provide instructions and services description by water resources consulting companies, who can meet software requirements. In this case, it can be said that this method is close to actual results.

6- It should be noted that this method and all method for rivers flood zoning determination, are only some tools to increase accuracy, in this case these methods with engineering judgment provide better and more acceptable results.

7- According to this area, a significant portion of farmlands, orchards, etc with a 25-years flood, damages significantly and it is necessary to reduce flood damages with river border determination as well as control plans execution.

Reference

1. Ismaili et al. 2008. Knchanchm river hydraulic behavior. Master's thesis.

2. Bagheri, A., 2005, zoning Garmrud river using hydraulic model HEC - RAS. Master's thesis. Chamran martyr of Ahwaz University.

3. Tavakoli, M. 2001. flood hazard zonation and characterization of it as part of Atrak between. Master's thesis. Gorgan University of Agricultural Sciences and Natural Resources.

4. Haghgoo, K 2001. Assess the impact of regulatory practices Ghazmhlh Kordkoy the hydrological characteristics of the river. Master's thesis Watershed Management, Gorgan University of Agricultural Sciences and Natural Resources.

5. Ghazimahaleh, N. 2007. Now Kandeh versatile performance of the structure of Golestan province in flood control. Journal of Agricultural Sciences and Natural Resources Volume 15, number one, especially a natural resource.

6. Report erosion and sedimentation basin thirty Shirvan Valley. 2011. Development consulting company movers Tehran.

7. Report Shirvan valley basin physiographic CD. 2011. Development consulting company movers Tehran.

8. Shirvan Valley watershed hydrology reports CNN. 2011. Development consulting company movers Tehran.

9. Weather report Valley watershed thirty Shirvan. 2012. Development consulting company movers Tehran.

10-Nikokar, M. 2008. Evaluation of Watershed Management actions and priorities on flood basin in terms of flooding using mathematical models (A Case Study of Golab - Darband). Fifth National Conference on Watershed Management Science and Engineering Iran.

11- Lammersen , R.Engel, H. vande lange m heen , w , Buiteveld, H.

12- Roshani, R. 2003. Evaluating the effect of chekdams on flood peak to optimize

13- Tate, E.C., Olivera , F., and Maidement, D., 1999. Floodplain Mapping Using HEC _RAS and Arc View GIS. Center for Research in Water Resources.