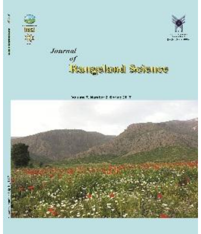
Contents available at ISC and SID

Journal homepage: www.rangeland.ir



Research and Full Length Article:

Assessing the Impact of Land Use Changes and Rangeland and Forest Degradation on Flooding Using Watershed Modeling System

Nafise Moghadasi[A*], Iman Karimirad[B] and Vahedberdi Sheikh[C]
[A]M.Sc. Student, Department of Watershed Management, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran, [*](Corresponding Author), Email: nafisehmogadasi@yahoo.com
[B]Ph.D. Candidate, Dept. of Irrigation and Reclamation Engineering, Faculty of Agricultural Engineering and Technology, College of Agriculture and Natural Resources, University of Tehran, Tehran, Iran
[C]Associate Professor, Dept. of Watershed Management, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran

Received on: 24/10/2015
Accepted on: 20/08/2016

Abstract. Extensive flood damages all over the world necessitate its control and operation. Hydrologic impacts of land use change appear in many ways such as total runoff, and flood peak flow. This study was performed in 2014 and aimed to investigate the impacts of land use changes on the occurrence of floods in the catchment of Boostan dam in Golestan province, Iran. For this purpose, Watershed Modeling System (WMS) was used to compare land use areas in 1996 with those in 2006 using the corresponding maps. After the calibration and validation of model in each period, rangeland and forest degradation and its effect on the flooding of catchment were evaluated using two representative parameters of peak flow and volume of flood. Land use maps of both time periods were compared and the achieved results revealed that the total area of rangeland was increased whereas good rangeland areas were decreased, fair rangelands were increased and poor rangeland areas were remained relatively constant that mean a decrease in high quality rangelands in the catchment. Also, the forest areas that decreased intensified flood. But peak flow and flood volume of the whole catchment have been mitigated. In spite of negligible change in total Curve Number (CN) of the catchment, rangelands in downstream and near residential areas converted to the agricultural lands and upstream agricultural lands converted to high and medium density rangeland. This means that distribution of land use changes was in such a way that influential upstream watersheds in flooding were associated with the reduced CNs. So, the implemented biological measures have reduced the flooding potential of the catchment. Sensitivity analysis of the model showed that 5% decrease in CN can cause 40% decrease in peak flow of the catchment and in contrast, 5% increase in CN can enhance flood peak flow up to 60%.

Key words: Flood, Sensitivity analysis, Curve number, Boostan dam

Introduction

Due to extensive flood damages to resources, especially soil and water, its control and operation are one of the main policies of watershed management (Meftah Helghi *et al.*, 2010). Hydrological response of a watershed is representative of a bunch of its conditions and characteristics and so, land use changes may affect the performance of watershed (Miller *et al.*, 2002). Hydrologic impacts of land use and land cover change appear in many ways such as total runoff, base flow, flood peak flow, soil moisture, and evapotranspiration. (Sikka *et al.*, 2003).

Watershed is a complex open system that it should be modeled to achieve the desired objectives such as assessment, and forecasting. Through the modeling of complex systems, the cost of studies will reduce and it will be possible to predict how to manage the watershed for future. One of the applications that are capable of geometric and hydrological modeling of watershed is the Watershed Modeling System (WMS) (Jajarmizade *et al*., 2012). WMS was developed by Brigham University researchers in 1998 in cooperation with the United States army corps of engineers. Due to the variety of appropriate hydrologic and hydraulic models included in WMS, experts use it to assess the watershed management projects.

Checking the status and information about the annual damages due to flooding in Iran and whole of the world indicates the impact of this phenomenon on natural resources. Therefore, it is inevitable to develope the integrated programs to curb, control and utilize the flood using appropriate management measures (Brouwer and Van, 2004). Our understanding of the effects of mechanical and biological activity on watershed response to rainfall is one of the key issues in the watershed management and flood control studies. Implementation of any treatments in the watershed is associated with the changes in Manning's roughness coefficient, time of concentration, vegetation and soil permeability change. So, it can cause some changes in rainfall-runoff relationship of the watershed and eventually, flood peak discharge (Simonovic, 2002).

Many researchers investigated land use changes in different places. Ariapour *et al.* (2013) studied land use changes of Barabad-Darook village in Sabzevar city, Iran during 1987-2007 using remote sensing. Results indicated that third-rated and first-rated rangelands have been decreased from 6.85 to 4.14 percent and from 0.03 to 0.01 percent, respectively. Also, the irrigated agricultural lands are to be decreased from 6.53 to 0.07 percent during a 20 year period. Nasri et al. (2013) in Ardestan, Iran used GIS and showed that almost 31% of the total area of the region had undergone some changes during a 30 year period. Also, Hosseini et al. (2012) performed their study in Inche Shorezar site of Golestan province, Iran for nine years (1997-2005) to investigate the vegetation changes.

Several studies on WMS and relationship between land use changes and floods have been conducted in Iran and abroad and some of them are mentioned here. Khosroshahi and saghafian (2005) used WMS and curve number (CN) parameter of sensitivity analysis and introduced it as the most sensitive parameter for calibration. Saghafian *et al.* (2006) evaluated the effects of land cover changes on peak flow and volume of flood in Golestan dam watershed located in Golestan Province in the northeast of Iran. Results showed that the 5-year flood peak flow increased up to 31.7% because of land use changes and destruction of forests and pastures. Gholami *et al.* (2009) assessed the effect of changes in land use on runoff generation and flood risk in Kasilian watershed located in

Mazandaran Province, Iran. Their research results revealed that the runoff potential and flood risk increase in the region are caused by the changes in land use. Githui *et al.* (2009) studied River Nzoia catchment, Kenya in a time period with an increase in agricultural area from 39.6 to 64.3% and a decrease in forest cover from 12.3 to 7.0%. It caused a difference in runoff ranging from 55 to 68%. Hosseini (2012) studied the WMS model capability in determining the flood peak flow in Khuzestan province, Iran. The results showed that WMS models computed flood that had a good correspondence with the calculated values of empirical equations in Khuzestan province.

Asharf *et al.* (2014) assessed the impact of land use change on Rawal watershed, sub-Himalayan region hydrology. They observed a decrease over 16% in the scrub forest coverage whereas built-up land increased three folds during 1992-2010 that resulted in an increase of about 6% in the water yield and 14.3% in the surface runoff of the watershed. Razavizade *et al.* (2014) investigated the impact of land use changes on flood characteristics in Taleghan watershed, Iran using HEC-HMS model. Based on simulation results due to the changes in land use (decrease of agricultural land and increase ranges), peak flow and volume of floods in 2002 were compared with those in 1987 and it has been shown that they decreased to 17.16 and 6.13%, respectively. Also, checking the base time showed no changes in the study period. Rezaee Moghadam et al. (2015) examined the effects of changing land use and land cover on flooding in Alavian dam watershed, Western Azarbaijan Province, Iran. Their results indicated an increase in runoff and flood risk of the watershed due to land use and land cover changes. Beiglu *et al.* (2015) assessed the effects of land use and cover on Darband river flow regime in Tajrish region. They deduced changes in land use and land cover which caused an increase in surface runoff because there was no significant trend in rainfall data, and river flow had an upward trend. Also, Vahabzade *et al.* (2015) investigated the impact of land use changes on daily river flow in Ajerloo watershed located in Azerbaijan Province using HEC-HMS model. Their research showed that changes in land use made 86.8% increase in peak flow and 12.7% increase in runoff volume. Zadsar and Azimi (2016) studied the impact of land use changes on hydrological response in Gorganroud Watershed, Golestan, Iran using SWAT. Accordingly, biomechanical measures can reduce runoff up to 20.7%.

Although flood is mainly a function of climatic conditions, especially the amount, intensity and spatiotemporal distribution of rainfall, various features of watershed such as land cover, and land use consisting of rangeland and forest degradation are the other effective parameters. In this paper, the effects of land use changes, especially rangeland and forest degradation on peak flow of flood have been evaluated in Boostan dam catchment.

Materials and Methods

Boostan dam catchment is a part of Gorganroud basin in the east of Golestan province, Iran (Fig. 1). It drains approximately 1562 km^2 and is situated within 37˚23´to 37˚46´ northern latitude and 55˚26´ to 56˚4´ eastern longitude.

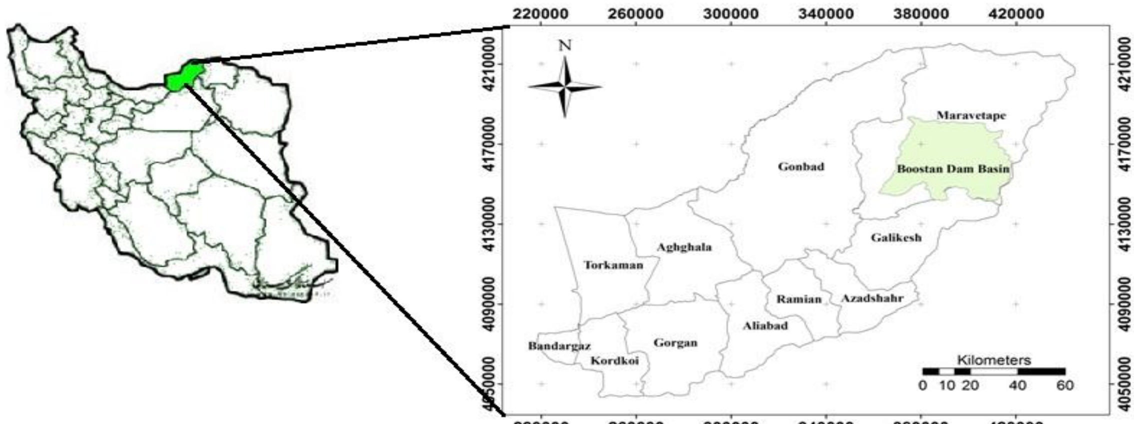
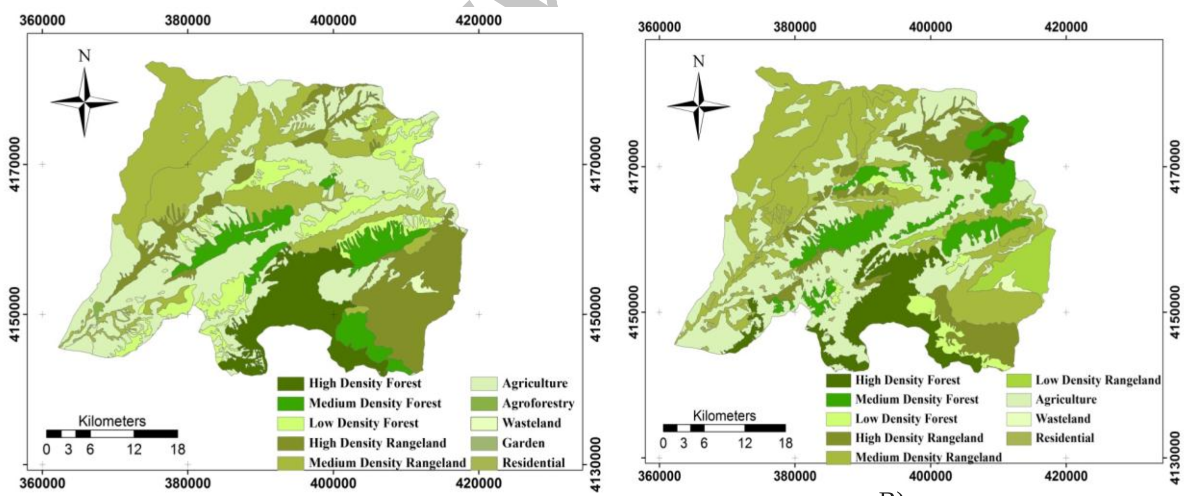


Fig. 1. The situation of Boostan dam catchment in Golestan province, Iran

In this paper, the impact of land use changes, and rangeland and forest degradation on runoff generation and flooding potential in Boostan dam catchment was studied by employing WMS (version 7). The investigation was performed in 2014. For this purpose, a digital elevation model (DEM) was prepared and land use maps of the catchment in two time periods of 1996 and 2006 (Fig. 2) were investigated in GIS. This time interval was chosen due to major watershed management measures of the region performed in these years. The investigation involves the amount of land use changes as well as its spatial distribution. So, the areas of each land use types such as forest, rangeland, and agriculture were calculated and compared between two periods. Then, the distribution of changes in upstream and downstream areas of each watershed was determined.



A) B)

Fig. 2. Land use map of Boostan dam catchment; A) 1996; B) 2006

In order to incorporate spatial distribution of land use changes, the catchment was divided into 14 watersheds using WMS. CN values were obtained and rainfall-runoff was modeled according to SCS[1] method (Cronshey, 1986).The model calibration was performed by optimizing the estimated curve number and the efficiency of optimized model was approved by comparing the observed and simulated hydrographs of real flood events. Some other flood hydrographs

[1] Soil conservation service

were used to indicate validity of the model. After validating the hydrological model of Boostan dam catchment, the effects of land use changes that caused changes in curve numbers were examined in several rainfall events. It should be noted that to investigate the impact of rangeland and forest degradation on the flooding of the catchment, two representative parameters of peak flow and volume of flood were considered.

Physiographic characteristics are main inputs of hydrological modeling software WMS. In order to calculate the physiographic characteristics of the catchment, 1:250000 topography maps of national cartographic center of Iran for 2006 have been used by the means of WMS software. Calculated values for each watershed of Boostan Dam catchment were shown in Table 1.

Table 1. Physiographic characteristics of Boostan Dam catchment

Watersheds	Area (KM^2)	Slope (m/m)	Average altitude (m)	Length of main stream (m)	Slope of main stream (m/m)
Kalshor	116.65	0.118	414.90	32580.5	0.013
Shordare	123.23	0.181	461.21	24668.4	0.015
Aghemam	143.02	0.192	548.49	20832.1	0.015
Chenarli	69.04	0.165	756.52	12495.7	0.022
Gharnave	94.97	0.239	934.82	19967.9	0.034
Karimishan	128.40	0.208	675.61	25972.3	0.026
Ghopan	46.19	0.174	396.39	13068.8	0.029
Azizabad	112.87	0.188	375.25	25304.3	0.011
Zav	135.01	0.245	906.04	17861.9	0.025
Golidagh	190.20	0.221	860.51	38121.7	0.015
Yelcheshme	265.01	0.161	1333.48	30862.5	0.028
sub-basin1	55.64	0.129	307.54	10875.7	0.017
sub-basin2	45.34	0.067	212.55	14189.6	0.011
sub-basin3	41.41	0.082	174.94	9477.4	0.015

Soil hydrologic group map is important and fundamental for a rainfall-runoff model in SCS method and the amounts of runoff depend on it. Map of soil hydrologic group of the catchment is presented in Fig. 3. In Figs. B and C, soil hydrologic groups have been represented with the permeability in range of 3.8-7.5 and 1.3-3.8, respectively.

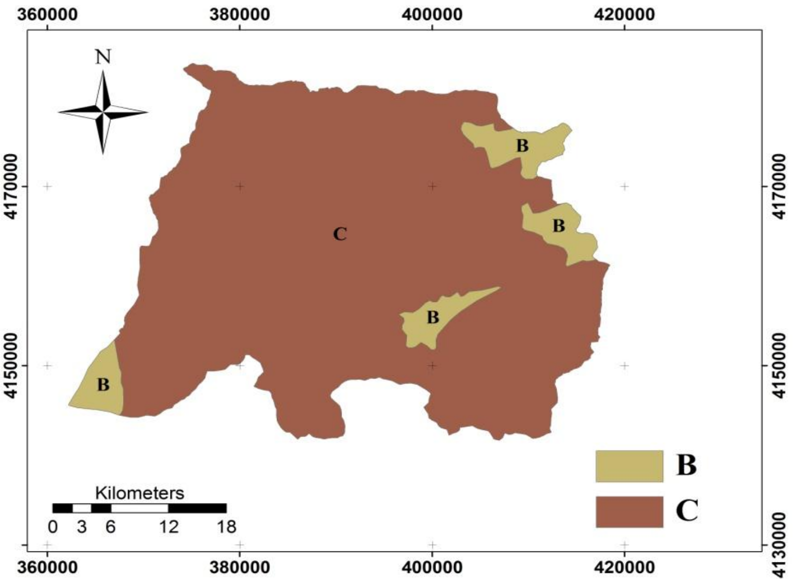


Fig. 3. Soil hydrologic group map of Boostan dam catchment

For mapping the curve numbers, each of land use maps of 1996 and 2006 was integrated with soil hydrologic group map in the WMS and then using the Table of CN, curve numbers per catchment were determined. Fig. 4 represents curve number map of Boostan dam catchment in 1996 and 2006. CN is a dimensionless number that is related to soil and cover conditions of the watershed and has a range of 0 to 100. CN=0 means no runoff and CN=100 means no infiltration and it is documented by SCS (2004).

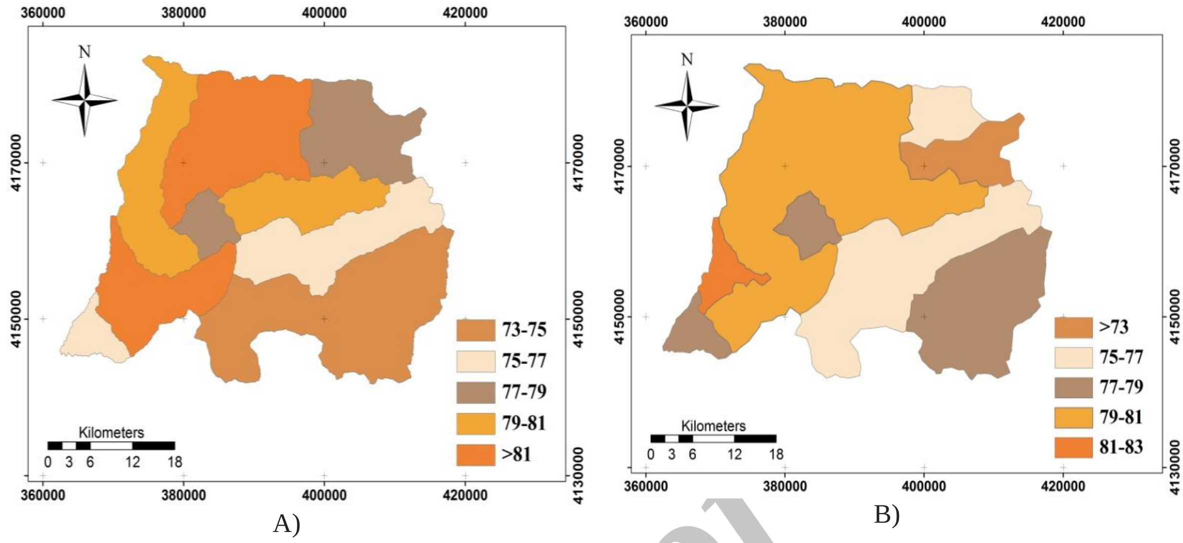


Fig. 4. The curve number map of Boostan dam catchment: A) 1996 and B) 2006

To simulate the catchment in WMS, flood hydrographs recorded in Tamar hydrometric station at the catchment outlet were investigated and to determine the corresponding rainfalls, daily rainfall records of rain-gauge stations in and around Boostan dam catchment provided by Golestan Regional Water Authority were used. Table 2 shows these stations' information.

Table 2. Information of rain-gauge stations in and around Boostan dam catchment

Station Name	Date of Establishment	Altitude m	Geographical coordinates	
			Latitude	**Longitude**
Tamar	1965	132	37°28´	**55°29´**
Park meli Golestan	1997	460	37°24´	**55°49´**
Gharnagh	1996	500	37°43´	**55°43´**
Golidagh	1996	1000	37°39´	**56°00´**
Pishkamar	1970	250	37°36´	**55°35´**
Zavebala	1997	700	37°31´	**55°45´**

It should be noted that in this paper, the automatic calibration of model was applied and the curve number was used as calibration parameter. In order to analyze the model results, the observed and simulated hydrographs of three flood events were compared using statistics of root mean square error (RMSE) indicating that the error rate given as zero is the best value for it (Willmott, 1981). Also, coefficient of determination (R^2) is between 0 and 1 and closer to 1 and the correlation between the observed data and computed values is better (Legates et al., 1999). Nash Sutcliffe efficiency index (E) was another statistic used in this paper that ranges from negative infinity to 1 meaning that the observation data and calculated ones are entirely corresponded (Nash and Sutcliffe, 1970). Finally, index of agreement (d) is between 0 and 1, and the values closer to1 show higher accordance between the observed and computed data (Legates et al., 1999).

Finally, the sensitivity of model to CN was analyzed to assess the effectiveness of this variable factor on floods in the region. In this paper, the sensitivity of flood peak flow at the catchment's outlet to the curve number was determined. For this purpose, the parameter changed from -10 to +10 percent and their impact on the flood discharge was determined.

Results

Land use changes were assessed using geographic information system. Land use maps have been prepared by Department of Natural Resources and Watershed Management in Golestan province. The results are presented in Table 3. Accordingly, the whole area of forests and rangelands decreased from 1060.36 to 1027.67 Km^2 in 10 years. Although the total area of rangeland increased by 17.24 Km^2, a high density rangeland decreased by 78.47 Km^2, medium density rangeland increased by 93.24 Km^2 and low density rangeland area remained relatively constant. This represents a decrease in rangeland quality of the catchment, which has a negative impact on its flooding.

Table 3. Land use distribution of Boostan dam catchment

Land use	1996		2006		Percent of change
	Total catchment (%)	Area (km^2)	Total catchment (%)	Area (km^2)	
Agriculture	32.20	508.31	33.76	533.02	4.84
Agroforestry	0.14	2.14	0.01	0.20	-92.86
Garden	0.05	0.81	0.02	0.30	-60.00
High-density forest	9.21	145.36	10.24	161.73	11.18
Semi-density forest	7.39	116.58	9.66	152.46	30.72
Low-density forest	9.07	143.19	2.60	41.01	-71.33
High-density rangeland	14.22	224.39	9.24	145.92	-35.02
Semi-density rangeland	23.48	370.44	29.56	466.68	25.89
Low-density rangeland	3.83	60.40	3.79	59.87	-1.04
Residential	0.10	1.51	0.74	11.65	640.00
Wasteland	0.31	4.83	0.38	6.01	22.58

Results also revealed that rangelands in downstream and near residential areas changed to agriculture. On the other hand, upstream agriculture areas in 1996 changed to high and medium density rangelands probably due to lack of precipitation. Also, some areas located in Golestan National park territory changed from medium density forest to medium density rangeland that can be caused by natural or anthropogenic factors that have a great importance in environmental aspect.

The other land use changes occur in this region have changed from a medium density forest to a low density forest. Moreover, some high density forests and low density forests have been cultivated. Of course, in few cases, a low density forest changed to a medium density forest.

Determined curve numbers using calibrated Boostan dam catchment model before and after the implementation of watershed management measures are presented in Table 4. As demonstrated in Table 4, the total catchment CN decreased from 78.21 to 78.05 that is ignorable.

Table 4. Curve number values of the watersheds in 1996 and 2006

Watersheds	1996	2006	Percent of change
Kalshor	80.06	79.66	-0.50
Shordare	81.51	80.52	-1.21
Aghemam	8170	79.94	-2.15
Chenarli	78.83	76.99	-2.33
Gharnave	78.04	70.29	-9.93
Karimishan	82.13	79.58	-3.10
Ghopan	78.94	78.07	-1.10
Azizabad	82.47	79.68	-3.38
Zav	73.44	75.14	2.31
Golidagh	74.48	75.73	1.68
Yelcheshme	74.42	78.82	5.91
Sub-basin1	80.95	80.50	-0.56
Sub-basin2	82.10	82.31	0.26
Sub-basin3	74.80	77.15	3.14
Total	78.21	78.05	-0.20

Soil moisture retention, lag time and time of concentration were calculated using SCS method and curve number (CN) values. These calculations were performed by WMS software for 14 watersheds. These parameters are shown in Table 5 for before and after the implementation of watershed management measures.

Table 5. Soil moisture retention, lag time and time of concentration for before and after the implementation of watershed management measures

Watersheds	1996			2006		
	soil moisture retention (mm)	Lag time (hr)	Time of concentration (hr)	Soil moisture retention	Lag time (hr)	Time of concentration (hr)
Kalshor	12.65	3.23	5.39	12.97	3.27	5.46
Shordare	11.52	2.56	4.28	12.29	2.64	4.41
Aghemam	11.38	2.19	3.66	12.75	2.31	3.86
Chenarli	13.64	1.89	3.16	15.18	1.99	3.32
Gharnave	14.29	2.10	3.51	21.47	2.62	4.38
Karimishan	11.05	2.40	4.01	13.04	2.61	4.36
Ghopan	13.55	1.78	2.97	14.27	1.83	3.06
Azizabad	10.80	2.49	4.16	12.96	2.72	4.54
Zav	18.37	2.23	3.72	16.81	2.13	3.56
Golidagh	17.41	3.86	6.45	16.28	3.72	6.21
Yelcheshme	17.46	3.92	6.55	13.65	3.44	5.74
Sub-basin1	11.95	1.73	2.89	12.31	1.75	2.92
Sub-basin2	11.08	2.83	4.71	10.92	2.80	4.68
Sub-basin3	17.11	2.53	4.23	15.05	2.36	3.94

Calibration and validation of WMS models were performed using three and two flood events in Tamar hydrometric stations, respectively. These flood hydrographs were shown in Figs. 5 and 6.

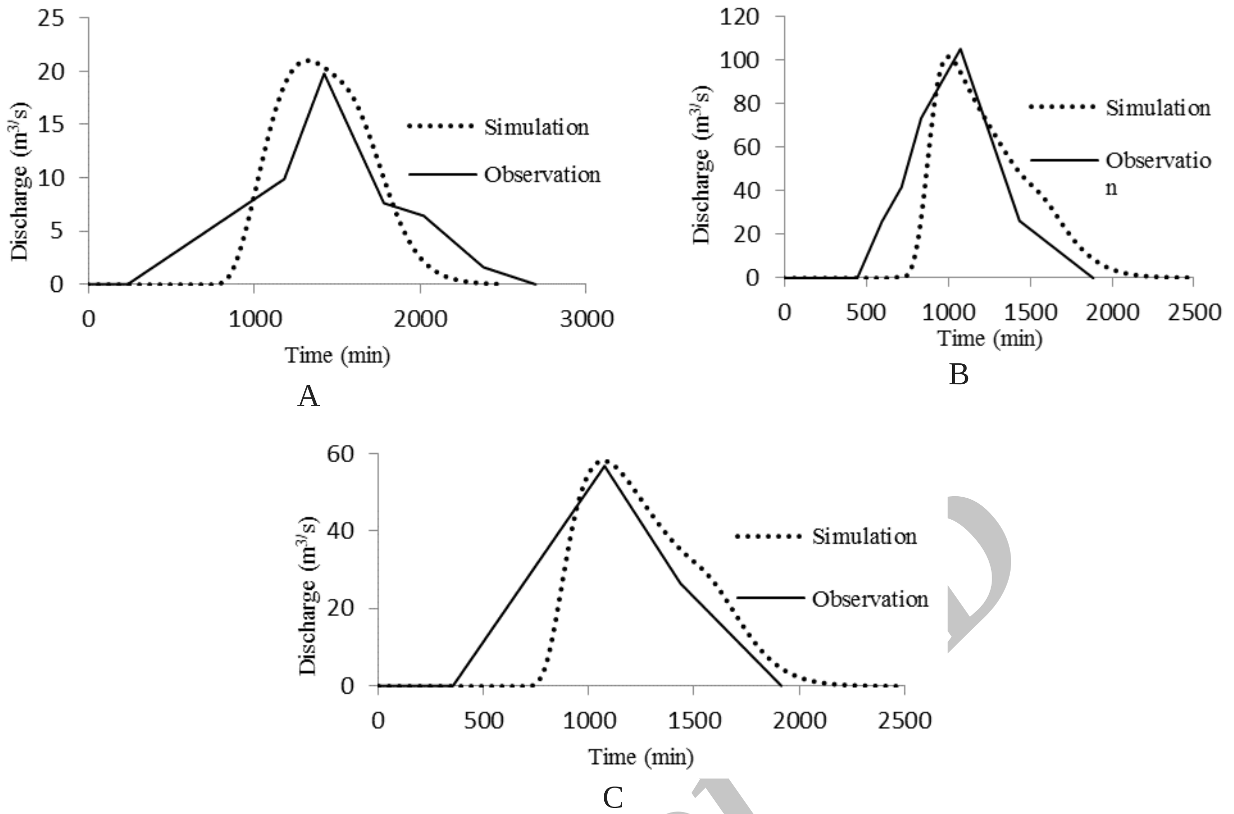


Fig. 5. Observed and simulated flood hydrographs in Tamar station (used for calibration) A) 11/6/1997 B) 5/30/1998 C) 9/11/1998

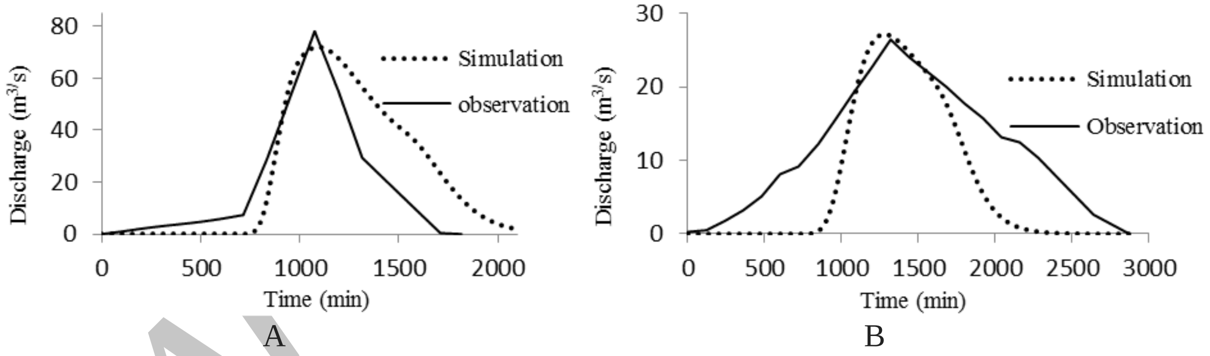


Fig. 6. Observed and simulated flood hydrographs in Tamar station (used for validation) A) 7/25/1998 B) 4/10/1999

The results of model verification indicate that there was a good coincidence between observed data and computed hydrographs in watershed modeling system. For example coefficients of determination values were between 0.87 and 0.92 which suggests a high correlation. Table 6 shows calculated statistics for the flood events used in model validation.

Table 6. Statistics for model performance evaluation in different flood events

Date of event	Index of agreement	Nash Sutcliffe efficiency index	Coefficient of determination	Root mean square error
1997/11/6	0.92	0.54	0.92	0.58
1998/5/30	0.93	0.74	0.87	0.66
1998/7/25	0.92	0.63	0.88	0.88
1998/9/11	0.93	0.75	0.87	0.64
1999/4/10	0.87	0.32	0.89	0.57

In Table 7, the impacts of land use changes due to rangeland and forest degradation on peak flow and volume of flood in different return periods are shown. The mentioned results show that for example, the mean 25-year peak flow decreased to 15% between 1996 and 2006.

Table 7. The impacts of land use change on peak flow and volume of flood in different return periods

Return period (years)	1996		2006	
	Peak Flow (m^3/s)	Volume flood ($1000m^3$)	Peak Flow (m^3/s)	Volume flood ($1000m^3$)
2	324.64	11213.59	283.72	11203.49
5	617.42	20424.06	531.52	20402.26
10	819.08	26579.50	701.29	26514.12
25	1076.05	34309.64	917.60	34188.83
50	1262.85	39820.19	1074.23	39668.44
100	1448.11	45265.43	1229.64	45075.48
200	1633.98	50697.64	1385.87	50473.60

Table 8 demonstrates different impacts of land use changes due to rangeland and forest degradation on peak flow and volume of flood in all 14 watersheds of the catchment in a 25 year return period.

Table 8. The impacts of land use changes on peak flow and volume of flood in different watersheds in a 25 year return period

watersheds	1996		2006	
	Peak Flow (m^3/s)	Volume flood ($1000m^3$)	Peak Flow (m^3/s)	Volume flood ($1000m^3$)
Kalshor	112.84	2823.06	114.04	2815.06
Shordare	140.76	2883.78	130.29	2739.41
Aghemam	179.70	3299.65	156.97	3011.69
Chenarli	91.14	1529.22	78.70	1384.95
Gharnave	118.74	2150.82	55.78	1321.51
Karimishan	163.52	3320.00	144.14	3003.88
Ghopan	66.51	1073.54	64.64	1044.43
Azizabad	152.88	3103.46	127.56	2734.36
Zav	113.04	2244.08	130.35	2468.34
Golidagh	122.40	3038.27	132.45	3750.61
Yelcheshme	163.48	4875.48	245.94	6348.19
sub-basin1	98.41	1533.42	102.71	1549.30
sub-basin2	56.35	1234.12	58.91	1261.53
sub-basin3	34.24	703.30	38.26	770.34

Sensitivity analyses investigate the model sensitivity to changes in CN of watersheds of Boostan dam catchment. In Table 9, changes in the flood peak flow of the catchment with the increase and decrease of CN in 2006 for each flood events are shown. Fig. 7 shows flood peak flow sensitivity to the changes in curve number.

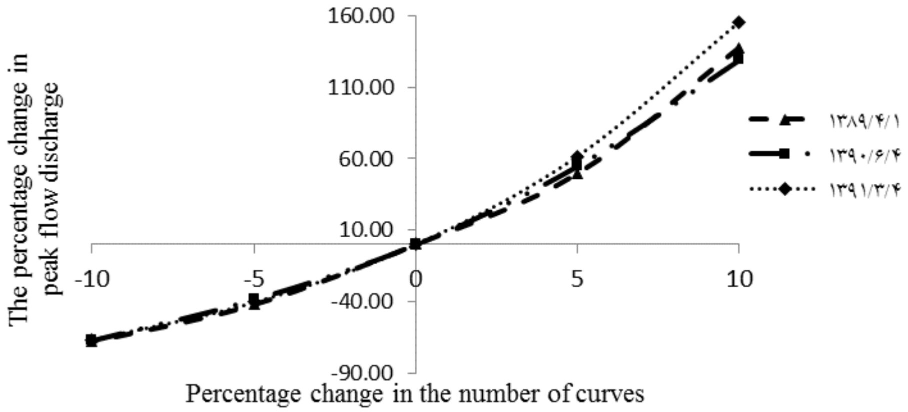


Fig. 7. Flood peak flow sensitivity analysis to changes in CN

Discussion

In this paper, hydrologic response of Boostan dam catchment was simulated with watershed modeling system in two periods of time. Land use map investigation showed that the study area has 11 types of land uses. Assessment of changes in land use of Boostan dam catchment in the period of 1996 to 2006 indicates that due to deforestation, more than 1.56% of the area is added to the farm lands. According to the results during the 10 year period, the total forest area has decreased from 25.67 to 22.50% and in contrast, the rangeland area has increased from 41.53 to 42.63%. So, the total forest and rangeland land uses in the catchment decreased almost 3%. Moreover, in this period, high density rangeland decreased to 78.47 Km^2 as 35.02% of its initial area, semi density rangeland increased to 96.24 Km^2 that means 25.89% of its initial area and low density rangeland area remained relatively constant. This represents a decrease in rangeland quality of the catchment, which has a negative impact on its flooding. On the other hand, residential area increased more than seven times that has a negative impact on flooding too.

According to statistics, simulated hydrographs were modeled properly as compared to the observed ones so that the index of agreement ranges from 0.87 to 0.93, coefficient of determination (R^2) is from 0.87 to 0.92, root mean square error is from 0.66 to 0.58 and Nash Sutcliffe efficiency indices are between 0.32 and 0.75. So, the model showed a good performance that corresponds with the results reported by Hosseini (2012).

In spite of above mentioned land use changes that all had a negative impact on flooding, the peak flow of modeled floods reduced. For example, the 25-year peak flow was decreased to 15% that is in contrast with the results reported by Githui *et al.* (2009) as well as Asharf *et al.* (2014). The key issue in this problem is the distribution of changes that can be represented as the novelty of this paper. There were rangelands in downstream and near residential areas that changed to agriculture and upstream agriculture ones changed to high and medium density rangelands. So, despite negligible changes in total CN of the catchment, changes were in such a way that curve numbers of high slope areas in upstream lands that are effective in generating flood have been reduced in a way that had a decreasing impact on flood characteristics. It can be concluded that the implemented biological measures during this period have been effective to mitigate floods of the catchment. Results of the sensitivity analysis emphasized on the importance of curve number parameter that is used to calibrate the model and it corresponds with Khosroshahi and Saghafian (2005). The sensitivity analysis showed that if CN reduced to 5%, peak flow of the catchment would decrease as 40% and on the other hand, 5% increase in CN will increase flood peak flow up to 60% that prove the importance of biological watershed management measures and prevention of forest and rangeland degradation.

Reference

Ariapour, A., Dadrasi Sabzevar, A. and Toloee, S., 2013. Estimation of Vegetation and Land Use Changes Using Remote Sensing Techniques and Geographical Information System (Case Study: Roodab Plain, Sabzevar City). Journal of Rangeland Science, 4(1), 1-13.

Asharf, A., Naz, R., Wahab, A., Ahmad, B., Yasin, M. and Saleem, M., 2014. Assessment of Landuse Change and Its Impact on Watershed Hydrology Using Remote Sensing and SWAT Modeling Techniques—A Case of Rawal Watershed in Pakistan. International Journal of Agricultural Science and Technology, 2(2): 61-68.

Beiglu, M.J., Hoseini, S.M. and Riahi, S., 2015. The effects of cover and land use change in Tajrish area on discharge regime in Darband River, Jour. Quantitative Geomorphologic Research, 3(3): 95-113. (In Persian).

Brouwer, R. and Van, E.K., 2004. Reintegrated ecological, economic and social impact assessment of alternative flood control policies in the Netherlands. Ecological Economics, 50: 1-21.

Cronshey, R., 1986. Urban hydrology for small watersheds. US Department of Agriculture, Soil Conservation Service, Engineering Division, 1-10.

Gholami, V., Bashirgonbad, M., Ozdi, M. and Jokar, I., 2009. Effect of changes in land use to create runoff and flood risk Kasilian watershed, Jour. Watershed Management Science and Engineering, 3(9): 55-57. (In Persian).

Githui, F., Mutua, F. and Bauwens, W., 2009. Estimating the impacts of land-cover change on runoff using the soil and water assessment tool (SWAT): case study of Nzoia catchment, Jour. Hydrological sciences, 54(5): 899-908.

Hosseini, S. A., Khatir Namany, J. and Akbarzadeh, M., 2012. Studying the Vegetation Changes of Natural Rangelands in Inche Shorezar of Agh Ghala, North Golestan Province, Iran. Journal of Rangeland Science, 2(4): 615-624.

Hosseini, Y., 2012. WMS model assessment in determining the maximum flood discharge in Khuzestan province. Presented at the first national conference on strategies for achieving sustainable development in agriculture, natural resources and the environment, Tehran. (In Persian).

Jajarmizade, M., Hasonizade, H. and Abasi Chenari, S., 2012. Evaluation of Capability of WMS model in watershed simulation and virtual walls' behavior on geometric simulation accuracy. Presented at the first national conference on sustainable development in arid and semi arid areas, Abarkoh. (In Persian).

Khosroshahi, M. and Saghafian, B., 2005. Routing role of the river in the identification and resolution of flood- prone areas in the watershed. Presented at the fifth Conference on hydraulic, Shahid Bahonar University of Kerman, Iran. (In Persian).

Legates, D. R. and McCabe Jr, G. J., 1999. Evaluating the use of "goodness-of-fit" measures in hydrologic and hydro climatic model validation. Water resources research, 35(1): 233-241.

Meftah Helghi, M., Zanagane, M.E., Karimirad, I., Akhzari, D., Yavarzade, M., 2010. Structural measures on water resources management, watershed Kashydar. Presented at the second national conference on integrated water resources management, Shahid Bahonar University of Kerman. (In Persian).

Miller, S.N., Kepner, W.G., Mehaffey, M.H., Hernandez, M., Miller, R.C., Goodrich, D.C., Devonald, K. D., Heggem, T., Miller, W.P., 2002. Integrating landscape assessment and hydrologic modeling for land cover change analysis, Jour. the American Water Resources Association, 38(4): 915-929.

Nash, J. E. and Sutcliffe, J.V., 1970. River flow forecasting through conceptual models. Discussion of principles. Jour. Hydro, 10(3): 282–290.

Nasri, M., Sarsangi, A. and Yeganeh, H., 2013. Detection of Land Use Changes for Thirty Years Using Remote Sensing and GIS (Case Study: Ardestan Area). Journal of Rangeland Science, 4(1): 23-33.

Razavizade, S., Salajeghe, A., Khalighi Sigarodi, Sh., Jafari, M., 2014. The effect of land use changes on flood characteristics Using HEC–HMS (Case Study: Taleghan watershed), Jour. Range and Watershed Management., 3(66): 373-386. (In Persian).

Rezaee Moghadam, M.H., Andriani, S., Almaspor, F., Valizade Kamran, Kh.,MokhtariAsl, A., 2015. Examine the effects of land use change and land cover on flooding and runoff (Case Study: Alavian Dam watershed), Jour. Hydro geomorphology, 1: 41-57. (In Persian).

Saghafian, B., Farazjo, H., Sepehri, A. and Najafinejad, A., 2006. The effect of land use changes on flooding in watershed Golestan Dam, Jour. Water Resources, 1(2): 18-28. (In Persian).

SCS: national engineering handbook, section 9: hydrologic soil-cover complexes, 2004. Soil conservation service, USDA, Washington, D.C.

Sikka, A.K., Sarma, J.S., Sharda, V.N., Samraj, P., Lakshmanam, V., 2003. Low flow and high flow responses to converting natural grassland into Bluegum (*Eucalyptus globulus*) in Nilgiris watersheds of south India, Jour. Hydrology, 2(70): 12-26.

Simonovic, S.P., 2002. Two new non-structural measures for sustainable management of floods. Water International, 27: 38-46.

Vahabzade, Gh., Navidi Far, Y., Habibnejad Roshan, M., Abghari, E., 2015. Investigating of the Effect of Land Use Changes on Daily River Discharge Using the HEC-HMS Model (Case study: Ajerloo Watershed, West Azerbaijan Province), Jour. Water and Soil Science, 4(24): 227-236. (In Persian).

Willmott, C. J., 1981. On the validation of models. Physical geography, 2(2): 184-194.

Zadsar, M. and Azimi, M., 2016. Using SWAT Model to Investigate the Impact of Rangeland Management Practices on Water Conservation (Case Study: Gorganroud Watershed, Golestan, Iran). Journal of Rangeland Science, 6(4): 309-319.

ارزیابی اثر تغییر کاربری اراضی و تخریب مراتع و جنگل‌ها در سیل‌خیزی بر مبنای سیستم مدل‌سازی آبخیز

نفیسه مقدسی[الف*]، ایمان کریمی راد[ب]، واحدبردی شیخ[ج]
[الف] کارشناسی ارشد مهندسی آبخیزداری، دانشگاه علوم کشاورزی و منابع طبیعی گرگان، *(نگارنده مسئول)، پست الکترونیک:
nafisehmogadasi@yahoo.com
[ب] دانشجوی دکتری مهندسی منابع آب، دانشگاه تهران
عضو هیئت علمی دانشگاه علوم کشاورزی و منابع طبیعی گرگان

تاریخ دریافت: ۱۳۹۴/۰۸/۰۲
تاریخ پذیرش: ۱۳۹۵/۰۵/۳۰

چکیده. خسارت‌های بزرگ سیل در سطح جهانی، کنترل و بهره‌برداری از آن را ضروری ساخته است. آثار هیدرولوژیک تغییر کاربری اراضی در شکل‌های زیادی از قبیل رواناب کل، دبی بیشینه سیلاب و غیره ظاهر می‌شود. این تحقیق در سال ۱۳۹۳ و با هدف بررسی اثرات تغییر کاربری اراضی بر وقوع سیلاب در آبخیز سد بوستان در استان گلستان، ایران صورت گرفت. به این منظور از سیستم مدل‌سازی آبخیز (WMS) برای مقایسه مساحت کاربری‌های اراضی با استفاده از نقشه‌های مربوطه در دو مقطع زمانی سال‌های ۱۳۷۵ و ۱۳۸۵ استفاده گردید. پس از واسنجی و اعتباریابی مدل در هر مقطع زمانی، میزان تخریب مراتع و جنگل‌ها و اثر آن در تولید رواناب این آبخیز با استفاده از دو پارامتر معرف جریان بیشینه و حجم سیلاب مورد ارزیابی قرار گرفت. نقشه‌های کاربری اراضی دو بازه زمانی مورد مقایسه قرار گرفت و نتایج آشکار ساخت که مجموع مساحت مراتع افزایش یافته است، این در حالی است که مرتع خوب کاهش، مرتع متوسط افزایش یافته و مساحت مربوط به مرتع فقیر تقریبا ثابت مانده است که بیانگر افت کیفی مراتع در این آبخیز می‌باشد. مساحت جنگل‌ها نیز کاهش یافته که هر دو سیل را تشدید می‌کنند. اما جریان بیشینه و حجم سیلاب کل آبخیز کاهش یافته است. زیرا با وجود تغییر اندک شماره منحنی (CN) کلی آبخیر، مراتع واقع در پایین‌دست و نزدیک مناطق مسکونی به کشاورزی تغییر یافته و زمین‌های کشاورزی بالادست به مراتع با تراکم زیاد و متوسط تبدیل شده است. به عبارت دیگر توزیع تغییرات کاربری اراضی به گونه‌ای بود که زیرحوضه‌های بالادست که در تولید سیلاب تاثیرگذار است، با کاهش CN همراه شد. بنابراین انجام اقدامات بیولوژیک، پتانسیل سیل‌خیزی این آبخیز را کاهش داده است. نتایج حاصل از آنالیز حساسیت مدل نشان داد که ۵ درصد کاهش در شماره منحنی، موجب ۴۰ درصد کاهش دبی اوج سیلاب شده و افزایش ۵ درصدی آن، تا ۶۰ درصد دبی اوج سیلاب را بالا خواهد برد.

واژگان کلیدی: سیلاب، آنالیز حساسیت، شماره منحنی، سد بوستان