Journal of Applied Sciences

ISSN 1812-5654

ANSInet
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Journal of Applied Sciences 9 (6): 1141-1146, 2009
ISSN 1812-5654

Regional Analysis of Low Flow in Karkheh and Karoon Watersheds

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Abstract: In this research, to evaluating of low flow from data of 28 hygrometry stations of Karkheh and Karoon basin, were analyzed and then flow duration curve was drew and discharge of parameters includes $Q_{75\%}$, $Q_{90\%}$, $Q_{92\%}$, $Q_{95\%}$ and $Q_{99\%}$ were calculated. Toward nomination of effective factors on low flow 21 parameters was detected such as physiographic, hydro climatic and geomorphologic, with geographic information system. With principal components analysis method we chose components which has less correlation. This component in regard of their importance include: weighted average slop of catchment, area, average elevation of catchment, compactness coefficient and slop of main channel which illustrate 80.5% of variation of data. In continue regional analysis with multivariate regression to establish relations between low flow and catchment's characteristics. Finally regard to comparing and assessment the accuracy of estimating methods, we used 9 control stations data and then we compared the amount of discharge of low flow-on the base of-achieved models with the amounts of control stations and finally the results shown that obtained models in this area were significant (at 99% level).

Key words: Flow duration curve, low flow, principal component analysis, multivariate regression, Karkheh, Karoon

INTRODUCTION

Whenever purpose of planning is using of stream flow of rivers and also river regime was distorted by domestic's people then detection and sufficient concept of characteristics and situation of low flow in targeted catchment is vital. This concept must be quantitative which is more important in urban areas that contagious diseases, chemical and thermal pollutions are of significant importance. Certainly that water tension is more obvious in drought and one of consequences of drought is decrease stream flow of rivers and this make damages in different aspects. For example decrease of stream flow of rivers cause increasing concentration of pollution and since decrease in oxygen concentration. This is leading in aquatic mortality and damage to environment and also to urban, industrial agricultural damage. On the other hand in using management of storage dams and hydro powers in drought period, an analyzing of low flow is very important.

Most of study shown estimate of low flow is more difficult of other flows (Henry, 1980). Characteristic of low flow is relevant to catchment's characteristic and climate variables. The most characteristic of catchments and climate which influence on low flow include area, mean of annual precipitation, length of main channel, percent of lakes and forest area, shape of catchments, girth of catchment and mean height of catchment (Smakhtin, 2001).

To evaluate relation of low flow with catchment's characteristic in 23 catchments in west Massachusetts and use 3 parameters such as: watershed area, average basin slope and base flow recession constant (Vogel and Kroll, 1992). In one study at 63 hydrometric stations on USA Texas river due to evaluation of low flow, determine that effective factors of low flow was drainage area, channel length, slope of catchment, basin shape factor, mean annual precipitation, predominant hydrologic soil group and the 2 year 24 h precipitation (Rifai *et al*., 2000). In another study in South Taiwan evaluated regression models 34 catchments by Yu *et al*. (2002) and they concluded that the most relation of low flow is with area, slope of catchment. Suresh *et al*. (2003) in Himalaya basins of Nepal, in order to study water resources and to estimate low flow, used of regional analysis method and understand that the relation between low flow with physiographic and geology in catchment is significant. In Zimbabwe, Mazvimavi *et al.* (2004), in a research on seasonal rivers in order to study low flow on 52 catchments, shown that

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low flow has relative relation with mean annual precipitation, slope of catchment, daring density and negative relation with evapotranspiration. Eslamian *et al*. (2004) in order to study low flows in Mazandaran catchment used of multiple regression to establish relation between low flows and catchment characteristic and finally introduce 3 factors as important such as: area, average of height catchment and average of slope catchment. Samiee *et al*. (2005) in research in order to regional analysis of low flow in the 12 hydrometric stations in Tehran find out 4 parameters which include area, average annual precipitation, average weighted infiltration and average slope of the catchment.

MATERIALS AND METHODS

Study area: Study area consists of two catchments, Karkheh and Karoon which are one of Persian golf's hydrology divisions. Karkheh basin is located in between 30° 58´ to 34° 56´ north latitude and 46° 60´ to 49° 10´ east longitude and Karoon basin is located in between 30° 20´ to 34° 5´ North latitude and 48° 10´ to 52° 30´ east longitude, Fig. 1 shows present study area. The present research was conducted from 2007 till 2008.

Methodology: With hydrologic plans of study area finally 138 hydrometric stations were detected but 28 of them which have better condition about statistical period were selected (Fig. 2).

Calculating of discharge with multi duration: For production necessary parameters of related discharges ($Q_{75\%}$, $Q_{90\%}$, $Q_{92\%}$, $Q_{95\%}$ and $Q_{99\%}$). Firstly flow duration curve was drew for all of the stations and then with that pertained curves we production nominated parameters of discharge.

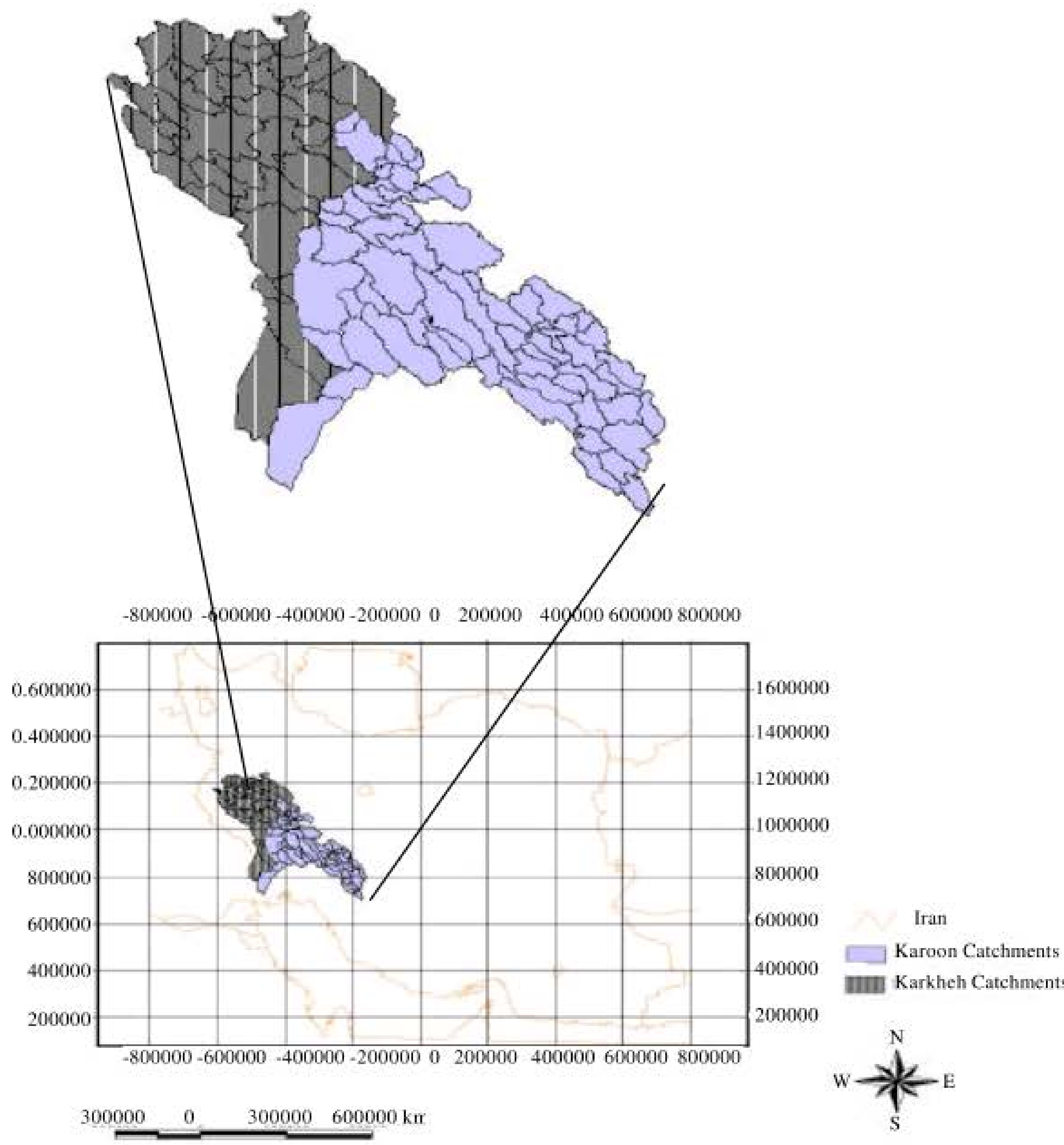

Fig. 1: Study area

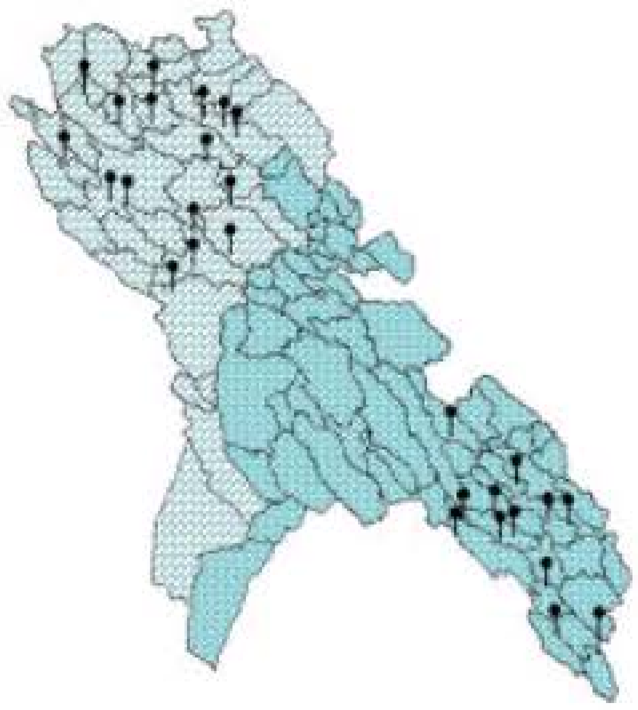

Fig. 2: Hydrometric station in the study area

Table 1: Total variance explained

	Initial eigenvalues		Extraction sums of squared loadings		
Component	Total	Cumulative (%)	Total	Variance (%)	Cumulative (%)
1	4.686	29.285	4.686	29.285	29.285
2	3.900	53.659	3.900	24.374	53.659
3	1.738	64.519	1.738	10.860	64.519
4	1.558	74.255	1.558	9.736	74.255
5	1.010	80.567	1.010	6.312	80.567
6	0.665	84.722			
7	0.580	88.348			
8	0.477	91.327			
9	0.449	93.883			
10	0.405	96.073			
11	0.356	97.549			
12	0.308	98.229			
13	0.293	98.567			
14	0.247	99.160			
15	0.2137	99.606			
16	0.05311	99.938			
17	0.009959	100.000			

Extraction method: Principal component analysis

Factor analysis: In this method we could decrease so many variables to fewer factors. And in this manner we could produce a summery of main data. Factor analysis was done for 16 variables in 28 selected stations in this study, because initially the results of factorial analysis is very complicated and not lead to a good problem solving so in order to maximize variance of any factor and simplifying the commentary of factorial structure, a factorial axis was shown by selection and indicator in each axis method. Final accepted method in order to establishment of factorial analysis was using of ordinary data and production of main components method, which were of similar answer to every of these methods: varimax rotation, non rotation varimax, qartimax and eqamax methods and finally varimax rotation method which is a popular one was determined as best method for selection of any factor. Meanwhile nomination of factors is also on the based on factor loads of varimax rotation. After selection of necessary variables, factorial analysis was done on the basis of these variables which the results shown.

RESULTS

That 5 of this express 80.567% of data variance. And so information is summaries around these factors. The percentages of every factor are, 29.3, 24.4, 10.9, 9.7 and 6.3, respectively (Table 1). This means that about 19.4% of whole variance didn't explained that could be increased by evaluation of additional variables. In order to varimax rotation matrix table (Table 2), weighted average slop of catchment with maximum weight load (0.844) on this factor and explanation of maximum percentage from whole variance which means the value 29.285, selected as the first factor. Also the second factor was the area of catchment because of weight load of 0.941 and percentage of 24.374 for variance. And then three other factors such as average elevation, compactness coefficient and slope of main channel was determined as third, fourth and fifth factors.

Multiple regression models: In regional analysis multiple regression method, is usually used for gain of revelation between flow characteristics and catchment's characteristics and some models introduce for flow estimation (1, 2 and 4). For accomplish regression, selected parameters which mentioned in Table 2 as an estimating variables and discharges of flow duration, main variable evaluated with two scales such as cubic meter per second (m^3 sec^{-1}) and millimeter (mm) and two simple logarithmic scale in analysis and finally with this method we achieve 60 models for 5 parameters discharge with different durations. Them finally we understand that logarithmic models with cubic meter per second (m^3 sec^{-1}) scale were the best and eventually we submitted one model for every evaluating duration (Table 3).

Comparing calculated with observed discharges: With use of gained equations, as finial models, discharges with duration of $Q_{75\%}$-$Q_{99\%}$ of time for 28 stations of Karkheh and Karoon catchments which gained from the model, we compared them with discharge flow duration statistics, then we got that they have significance of 99% and there relation coefficient between 77-79%. Result are shown in Fig. 3-7.

Table 2: Rotated component matrix

Standardization of parameter	Component 1	2	3	4	5
Watershed area	0.01664	0.941	0.09309	0.08216	-0.08841
Length of main channel	0.07793	0.936	0.09311	0.09199	-0.125
Slope of main channel	0.04247	-0.149	-0.136	0.07947	0.908
Maximum of elevation	0.676	0.315	-0.273	-0.308	-0.04478
Minimum of elevation	0.05212	-0.564	-0.648	-0.278	-0.135
Average elevation	0.197	-0.01112	-0.735	0.174	0.141
Perimeter	-0.0257	0.624	0.126	0.719	-0.05115
Compactness coefficient	-0.03533	0.05847	0.01118	0.971	0.03596
Weighted average slop	0.844	0.256	0.007613	0.07128	-0.05859
Base flow index	0.592	-0.04771	-0.195	-0.240	0.563
Permeability	0.729	0.05649	0.223	0.03242	0.536
Drainage density	-0.028	0.350	0.180	0.0435	0.235
Daily base flow recession constant	-0.543	0.163	0.557	0.333	0.168
Mean annual rainfall	0.826	-0.07927	-0.162	0.0474	0.187
Annual evaporation	0.439	0.04491	0.661	0.240	-0.134
Snow index	-0.163	0.325	0.779	0.04591	-0.08322
Mean annual runoff	0.355	0.715	0.315	0.01769	0.0102

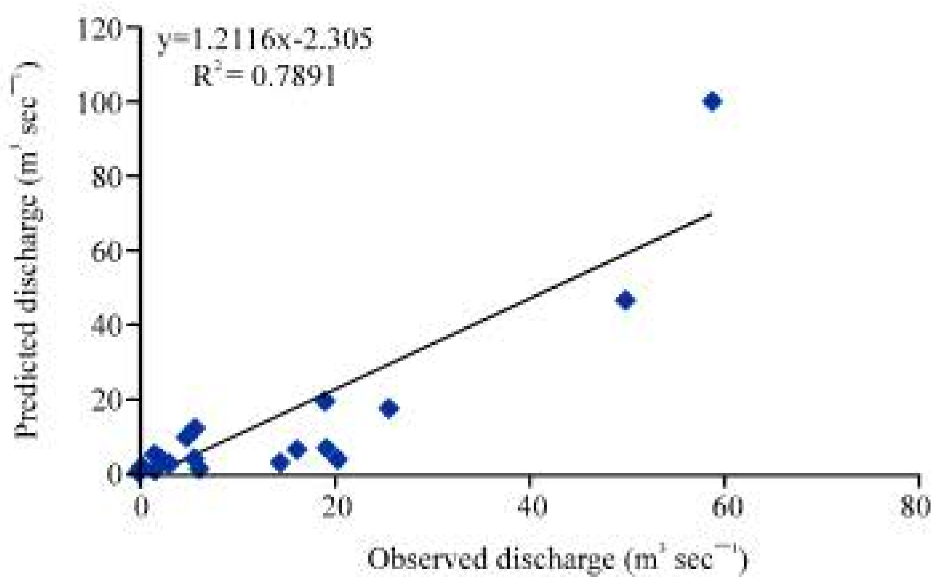

Fig. 3: Predicted discharge versus observed discharge values for $Q_{75\%}$

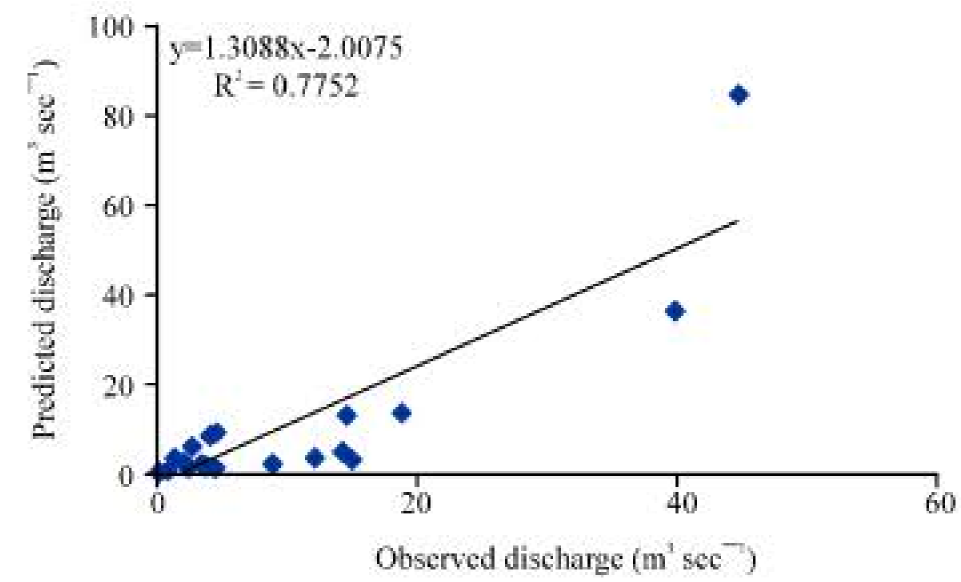

Fig. 5: Predicted discharge versus observed discharge values for $Q_{92\%}$

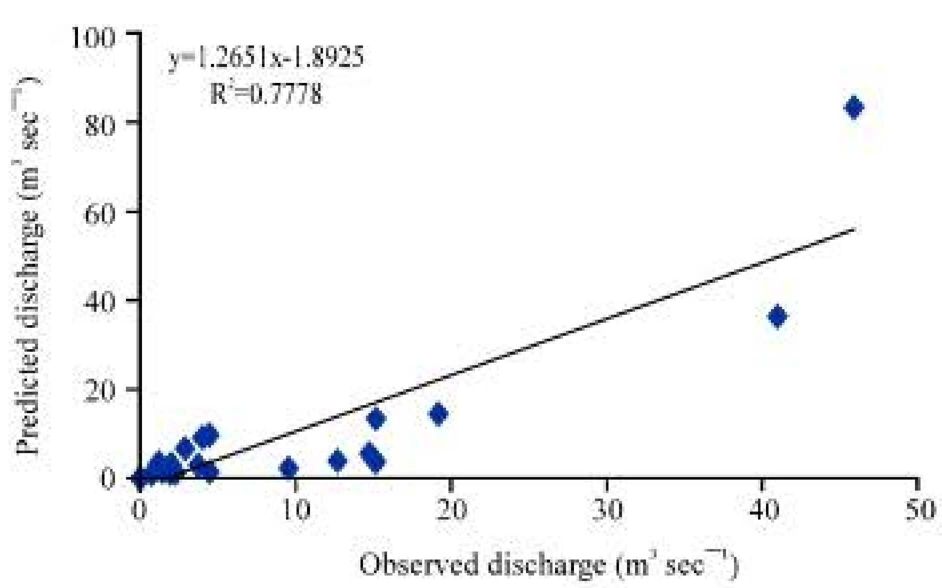

Fig. 4: Predicted discharge versus observed discharge values for $Q_{90\%}$

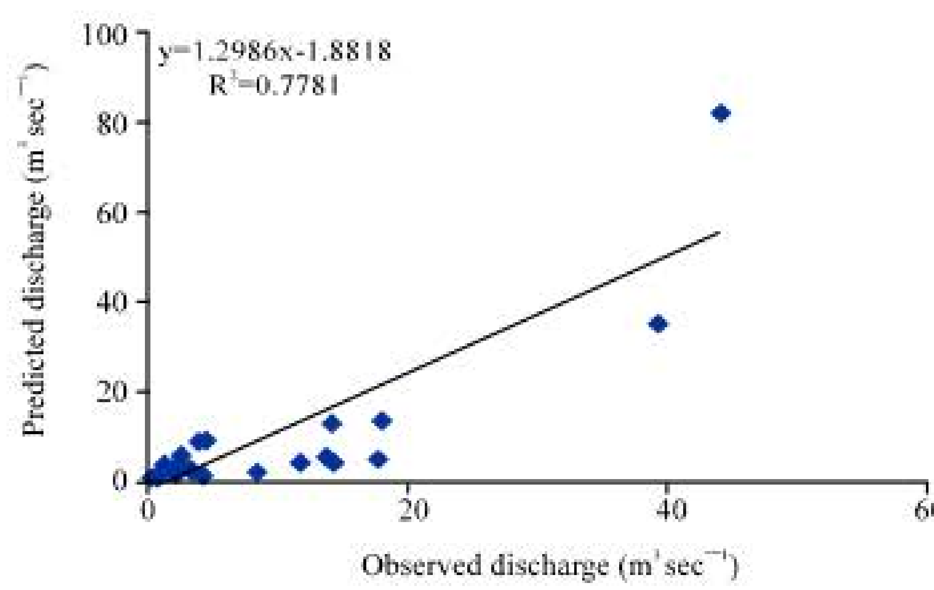

Fig. 6: Predicted discharge versus observed discharge values for $Q_{95\%}$

Evaluation and accuracy test model: Efficacy of models in assessment and approving were calculated with use of R-square indexes, standard error and efficacy coefficient. In Table 3 shown calculations of indexes above with selected models. Whatever R-square is higher, standard error is lover and efficacy coefficient is more near to one, shows that a model is better. In addition to mentioned parameters for evaluating gains models, we used of 9

Table 3: Final model for low flow by multivariate regression in the Karkheh and Karoon basins

Discharge	Model	p-value	SE	CE	R^2
$Q_{75\%}$	$Q_{75\%}=10^{-0.656\,I+4.265BFI-10.00115\,H\,min+0.569\,log\,A-0.982}$	0.99	0.386	0.53	0.743
$Q_{90\%}$	$Q_{90\%}=10^{-0.68\,I+4.983BFI-0.00119\,H\,min+0.562\,log\,A-1.483}$	0.99	0.400	0.75	0.749
$Q_{92\%}$	$Q_{92\%}=10^{-0.704\,I+5.116BFI-0.001221\,H\,min+0.567\,log\,A-1.516}$	0.99	0.405	0.82	0.753
$Q_{95\%}$	$Q_{95\%}=10^{-0.703\,I+5.258BFI-0.00123\,H\,min+0.572\,log\,A-1.651}$	0.99	0.410	0.82	0.750
$Q_{99\%}$	$Q_{99\%}=10^{-0.7371\,I+5.516\,BFI-0.00128\,H\,min+0.594\,log\,A-1.815}$	0.99	0.436	0.78	0.746

SE: Standard Error; CE: Coefficient Efficacy; R^2: R square; I: Permeability, BFI: Base Flow Index, H_{min}: Minimum of Elevation, A: Watershed Area

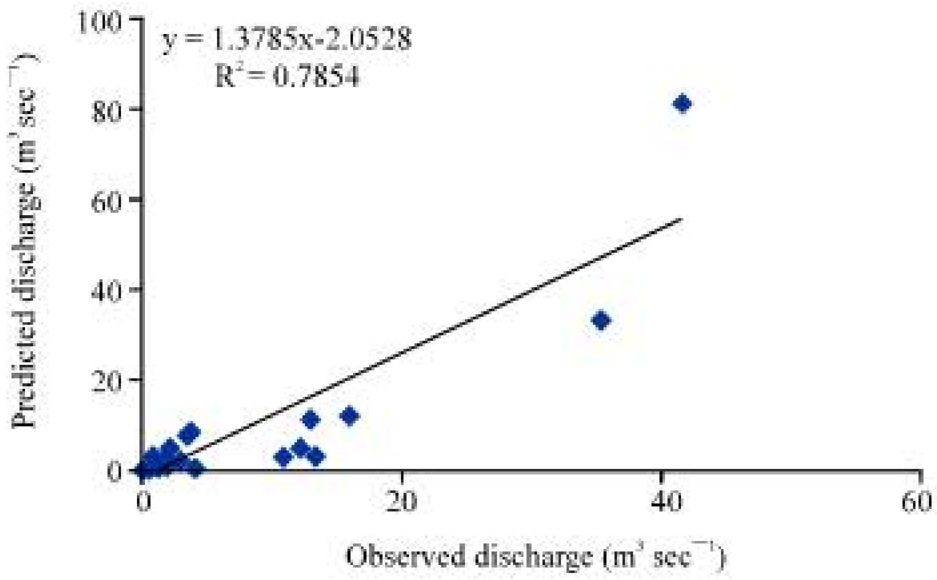

Fig. 7: Predicted discharge versus observed discharge values for $Q_{99\%}$

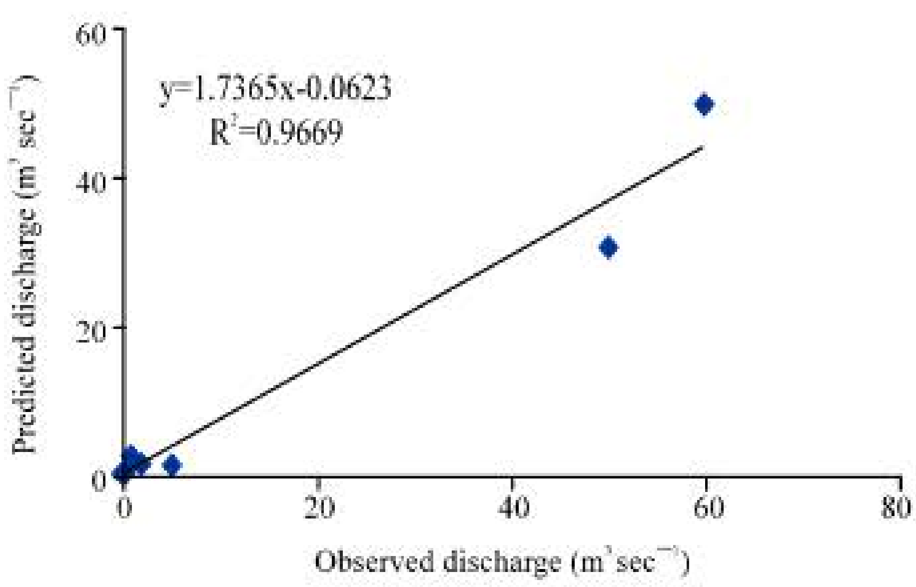

Fig. 8: Predicted discharge versus observed discharge values for $Q_{75\%}$(Accuracy test)

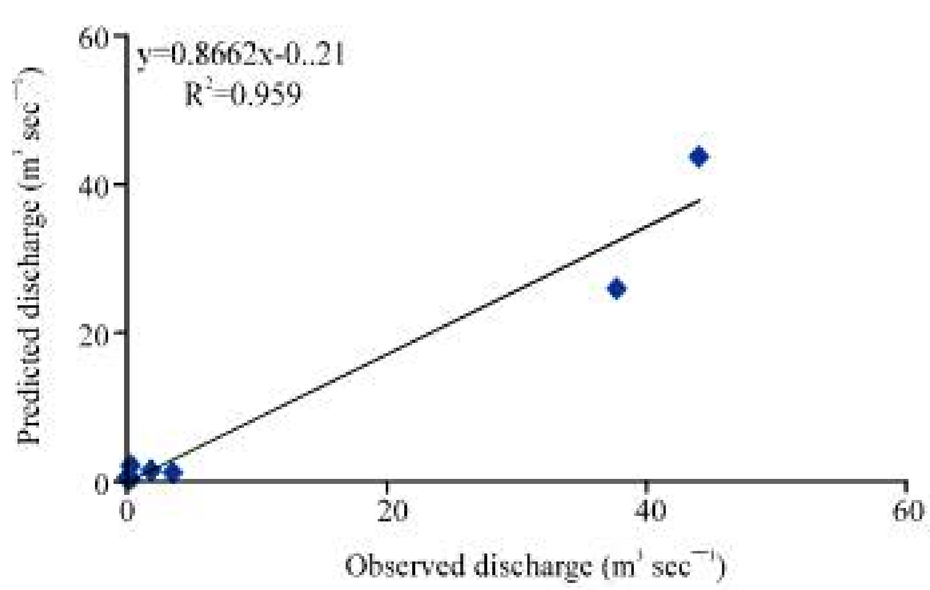

Fig. 9: Predicted discharge versus observed discharge values for $Q_{90\%}$ (Accuracy test)

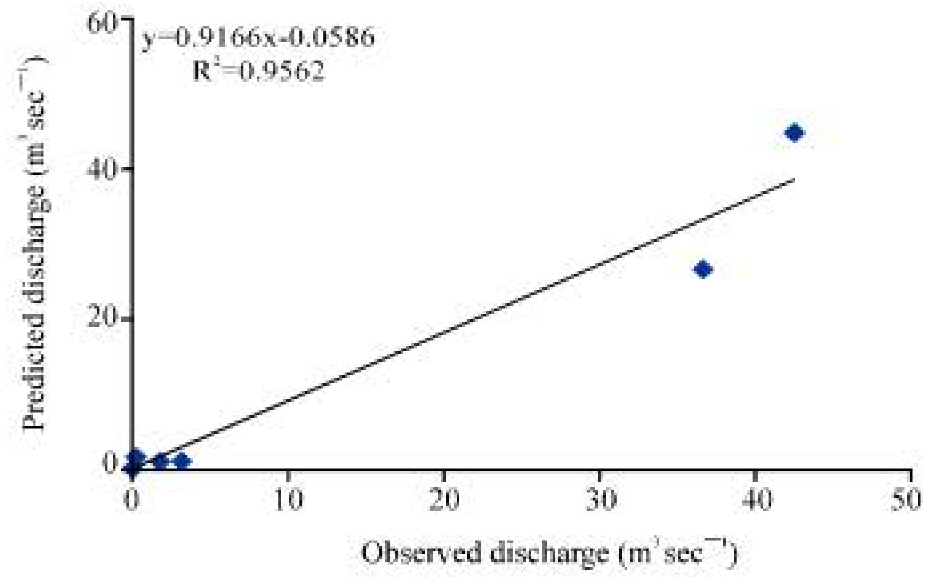

Fig. 10: Predicted discharge versus observed discharge values for $Q_{92\%}$ (Accuracy test)

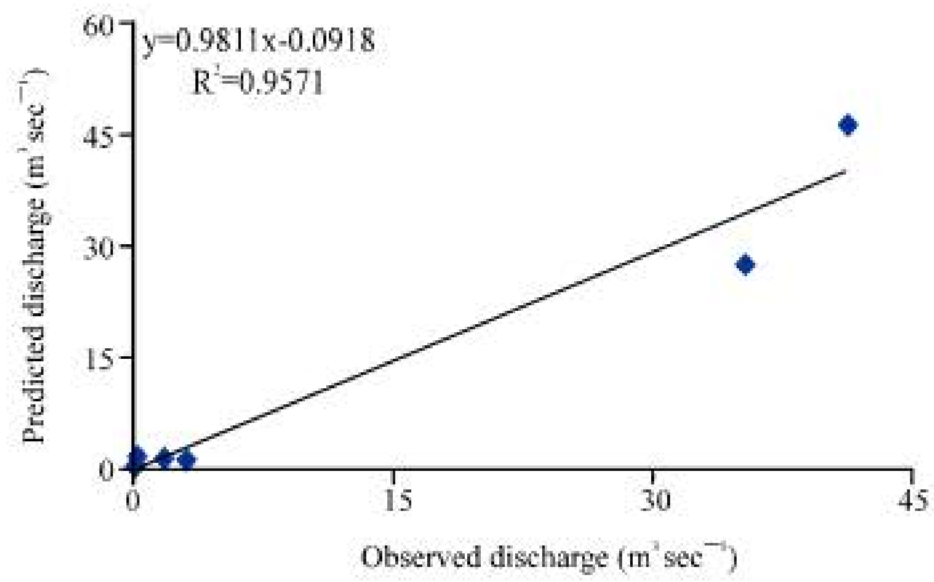

Fig. 11: Predicted discharge versus observed discharge values for $Q_{95\%}$ (Accuracy test)

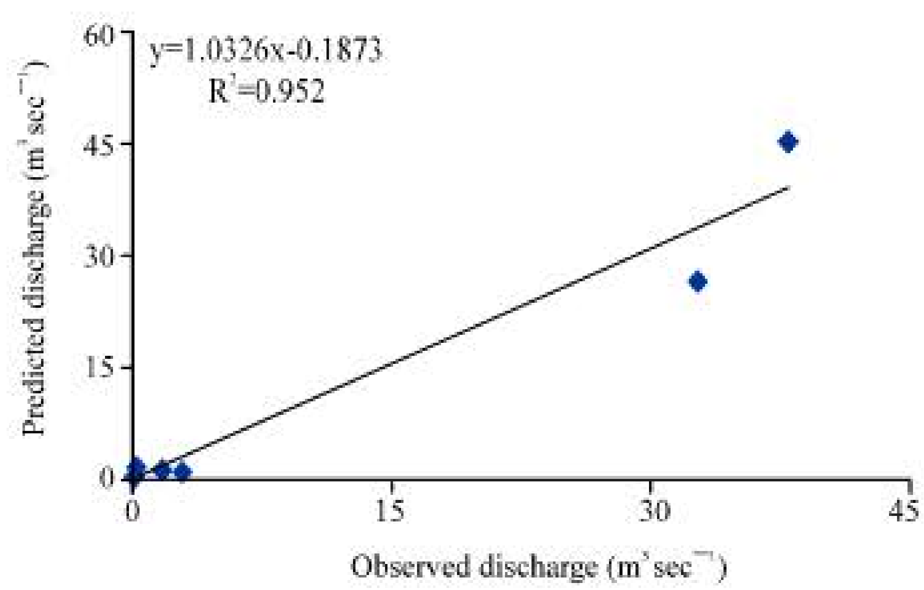

Fig. 12: Predicted discharge versus observed discharge values for $Q_{99\%}$ (Accuracy test)

stations parameters but not from 28 stations which were studied and didn't inter free in regression analysis. For this purpose we calculated 75-99% of time of discharges of flow duration, with the aid of equations which shown in Table 3 and parameters of 9 catchments that mentioned before and then compared with observed discharges of the same stations which finally we understand that they have 99% significance and a relation coefficient between 95 to 95%. Result are shown in Fig. 8-12.

DISCUSSION

Physiographic characteristics of catchment is always one of effective factors which has been mostly focused in earlier studies by Eslamian *et al.* (2004), Samiee *et al.* (2005), Vogel and Kroll (1992) and Suresh *et al.* (2003), but in this research in addition to physiographic parameters used climatic and geologic parameters as well. Finally in this research we used of 21 parameters to selected effective factors on low flows, we also we used of two parameters such as Base Flow Index (BFI) and Recession Constant Index. Which we can't see these 2 parameters in other Iranian studies. BFI is as an indicator to catchments out come and its own specific qualification, we can compare flow characteristics is different catchments with the aid of these index. Finally we introduce 5 parameters as effective factors on low flows which include: area, average slope, average height, coefficient gravilluse and slope of main channel.

Generally a most of researches the characteristics of area, average slop and average height include catchment area more important than others (Eslamian *et al*., 2004; Samiee *et al*., 2004; Smakhtin, 2001; Vogel and Kroll, 1992; Rifai *et al*., 2001; Suresh *et al*., 2003; Yu *et al*., 2002), but in this research in addition to these parameters the factors such as: coefficient gravilluse and slope of main channel was also introduced as important parameters. Which we can say that although main height of catchment doesn't has direct revelation with the low flow but it could illustrating how the catchment is snowy and also we could explain the cause of addition of the factor main slope of catchment with effect of average slope on daring speed (Eslamiyan *et al*., 2004; Dingman and Lawlor, 1995; Vogel and Kroll, 1992).

ACKNOWLEDGMENTS

We thank Trabiat Modares University (TMU), (http://www.modares.ac.ir) and we thank Soil Conservation and Watershed Management Institute of Iran (SCWMI), (http://www.scwmri.ac.ir), we thank of our wives whom support us every time. We thank of Dr. Mohammad Ashrafi (MD) whom helps us translation of our English.

REFERENCES

Dingman, S.L. and S.C. Lawlor, 1995. Estimating low flow quantiles from drainage basin characteristics in New Hampshire and Vermont. J. Am. Water Resourc. Assoc., 31: 243-256.

Eslamian, S.S., A. Zareie and A. Abrishamchi, 2004. Regional estimation of low flows for Mazandaran river basin. J. Sci. Technol. Agric. Natl. Resourc., 8: 27-37.

Henry, C.R., 1980. Characteristics of low flows. J. Hydraulics Div., 106: 717-731.

Mazvimavi, D., A.M.J. Meijerink and A. Stein, 2004. Prediction of base flows from basin characteristics: A case study from Zimbabwe. Hydrol. Sci. J., 49: 703-715.

Rifai, H.S., S.M. Brock, K.B. Ensor and P.B. Bedient, 2000. Determination of low flow characteristics for texas streams. Water Resourc. Plann. Manage., 126: 310-319.

Samiee, M., M. Mahdavi, B. Saghafian and M.M. Saravi, 2005. Regional analysis of low flow in Tehran Watershed. J. Natl. Resourc. Iran, 58: 51-64.

Smakhtin, V.U., 2001. Low flow hydrology: A review. J. Hydrol., 240: 147-186.

Suresh, C.S.R., G. Kansakar, K.R. Croker and M. Zaidman, 2003. Management of water resources and low flow estimation for the Himalayan basins of Nepal. J. Hydrol., 282: 25-35.

Vogel, R.M. and C.N. Kroll, 1992. Regional geohydrologic-geomorphic relationships for the estimation of low flow statistics. Water Resourc. Res., 28: 2451-2458.

Yu, P.S., T.C. Yang and C.W. Liu, 2002. A regional model of low flow for Southern Taivan. Hydrol. Process., 16: 2017-2034.