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Flood Hydrograph Analysis Through Employing Physical Attributes Using Two and Multiple Variables Regression Factor and Cluster Analysis (Case Study: Western Part of Jazmurian Watershed)

A. Salajegheh[a], S. Dalfardi[b*], M. Mahdavi[c], A. Bahremand[d]

[a] *Associate Professor, University of Tehran, Karaj, Iran*
[b] *Academic Staff, University of Jiroft, Jiroft, Iran*
[c] *Emeritus Professor, University of Tehran, Karaj, Iran*
[d] *Associate Professor, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran*

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Abstract

Since direct experimental evidence is not available, this must be verified through a modeling approach, provided adequate data be available**.** Many statistical methods are used to study the relation between independent and dependent variables.This research was carried out at the western part of Jazmurian basin located in the southeast of Iran. In this paperused ten physical characteristics such as area (A), perimeter (Pr), average elevation of basin (av.e), average slope (av.s), gravelious coefficient (G), length of main stream (L), pure slope of main stream (P), length of output to one point equivalent center of basin (Lc), Time of concentration (Tc) and lag time(Tl) as independent variables and nine hydrograph component such as Qp, Q25, Q50, Q75, Tp, T25, T50, T75 and Tb as dependent variables.We investigate flood hydrograph through the physical attributes using two and multiple variables regression factor and cluster analysis.With the data of twelve hydrometric stations. Normality test was done using Kolmograph-Smironov. After using four mentioned methods and with the use of modeling, the relations between dependent and independent variables weres defined. The evaluation of hydrologic model behavior and performance is commonly made and reported through comparisons of simulated and observed variables. Frequently, comparisons are made between simulated and measured stream flow at the catchments outlet. Significant models have correlation coefficient bigger than 0.325 at 0.01 significant level and higher than 0.250 at 0.05 significant levels. Three criteria such as root mean square error (RMSE), relative error (RE) and coefficient of efficiency (CE) were used for selecting the ultimate models. The results revealed that with the use of physical characteristics of the basin we can determine the synthetic hydrograph. The results also showed that the two- variable models have higher efficiency in estimating the discharge variables of the simulated hydrographs. After the cluster analysis for group in which are more station s, it results in more significance of the model than one whose group included less stations.

Keywords: Physical attributes; Hydrological modeling; Synthetic hydrograph; Dependent variable; Jazmurian basin; Iran

1. Introduction

We need to have discharge data as time series to illustrate hydrographs since there are no enough discharge information and hydrometric stations and also because of the good mathematical relationships between catchment characteristics and hydrograph properties and components we try to develop the synthetic hydrographs using the mentioned relationships (Surkan 1969). The relationship between physical characteristic of catchment and hydrograph component is very high (Arabkhedri 1989). For appropriate design of hydraulic structures and flood control structures, information must be known about the hydrology

* Corresponding author. Tel.: +98 936 9270498,
Fax: +98 348 2214757.
E-mail address: d_s2358@yahoo.com

of the system, such as peak flow, runoff volume, and the time to peak of large storm events. Many design applications including dams, spillways, detention basins, culverts, and urban storm water systems depend on these information. To accurately predict the peak flow, runoff volume, and time to peak of design storms, the hydrological processes, which control the rainfall-runoff phenomenon, must be investigated. (Rahimian, 1995). If there are enough statistical data of flood, it can be done using flood frequency analysis (Afshar 1990). Providing flood properties for the watersheds without statistical data is a hard task. Empirical formulas, Synthetic hydrograph, simulation methods, statistical estimations are analyzed and flood indicators are used for determination of maximum instantaneous flood in those watersheds without hydrometric stations. Among these methods, some which result in simulating hydrograph are able to describe the exact details of flood (Compolar & Solodati, 1999). In other words important necessary properties of flood can be derived after determining the flood hydrograph. But most of the time because of hydrographs limitations, the design flood hydrograph is obtained by another way for applications (Afshar, 1990). We need to have discharge data as time series to illustrate hydrographs, since there are no enough discharge information and hydrometric stations and also because of the good mathematical relationships between catchment characteristics and hydrograph properties and components, we were tried to develop the synthetic hydrographs using the mentioned relationships. Dooge (1977) comments that many of early models were based on empirical equations developed under unique conditions and used in applications with similar conditions. An urgent need in hydrology is to apply models for prediction in ungauged basins and hence traditional calibration of models is not possible (Sivapalan et al., 2003). Hydrological models are primarily predictive models, meaning they obtain a specific answer to a specific problem. Other models are developed to be investigative, meaning they increase our understanding of hydrological processes (O'Connell, 1991). There are many proposed models to calculate the synthetic hydrograph, they were used for special condition and could not be used in different locations (Afshar, 1995). The models are suitable instrument for decision making in hydrologic affairs and for developing these models doing accurate and effective watershed assessment is necessary (Deal et al. 2008). it was found that the neural network techniques demonstrated better performance in predicting the maximum discharge based on five independent variables than the regression techniques (Neslihan Seckin 2010).

Efficiency criteria are defined as mathematical measures of how well a model simulation fits the available observations (Beven, 2001). Models simplify the system and simulate watershed behaviors and represent the relations existed between the characteristics of basin and their hydrograph response. Therefore studying the affairs that take place in watershed and estimating its important outputs such as flood and sediment are of most important duties of watershed manager (Telvari 1996). Therefore hydrologic modeling provided by physical attributes can solve many of problems in relation with hydrologic studies. Because different locations in our country are under risk of frequent floods, hence developing these models is very necessary and by using these models we can save our different natural and humanity resources.

2. Material and Methods

The Jazmurian basin is located at southeast of Iran and is surrounded by Bazman, Jabalbarez, Hazar and Lalehzar mountains (Fig. 1). It is bounded by Bashagard Mountains at the south. All the rivers and streams of this basin inflow toward the Jazmoran plain. It is located between 56˚, 15´ until 61˚, 23´ east longitude and 26˚, 28́ until 29˚, 30́ north latitude. Its area is 69621 Km^2 of which about 32459 Km^2 is the area of plains and fans, and 3000 Km^2 salty area, wetlands and swamps. This research was carried out in western part of Jazmurian where the mountains are, and the main stream and rivers of the basin with an important role on flooding are located in this part. Baft and Esfandagheh plains are located at the farthest end of northwest of jazmurian watershed with high elevation. Some cities including Jiroft, Baft and Iranshahr are located in this basin.

The required information for this research included ten physical characteristics (independent variables) and components of flood hydrograph (dependent variables). The information concerning flood hydrograph is obtained from Iranian Water Recourses Management Company and also Regional Water Company of Kerman and physical characteristics are obtained from digitized topographic maps with scale of 1:50000 (sheets related to western part of Jazmurian).

Totally, 12 hydrometric stations were selected at the studied area (Fig. 2) (Table 1). After collecting required information of mentioned stations from related departments, hydrographs designed on coordinate axis and Hawk Belly hydrographs were selected.

Unfortunately because of different reasons such as taking unsuitable statistic data, most of hydrographs were unsuitable for modeling. In spite of this problem among the data of different stations, ninety one hydrographs suitable for modeling, were selected.

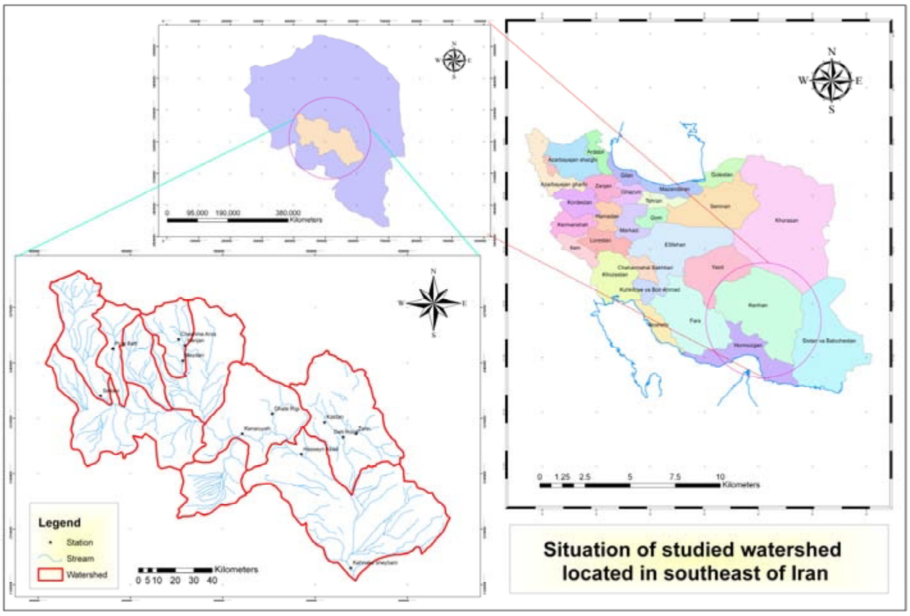

Fig. 1. Location of studied watershed in southeast of Iran

Table 1. Hydrometric stations in the studied watershed

No	Name of station	River	Catchment area (Km^2)
1	Soltani	Soltani	935
2	Koldan	Rabor	191
3	Ghaleh rigi	Ramon	249
4	Konaroieh	Halil rood	7600
5	Zarin	Saghder	330
6	Dehrod	Shor	1361
7	Hosein abad	Halil rood	8420
8	Meydan	Seyed morteza	520
9	Hanjan	Rodar	311.2
10	Poleh Baft	Baft	261
11	Chashmeh Aroos	Rabor	100.4
12	Kahnakeh sheybani	Halil rood	12990

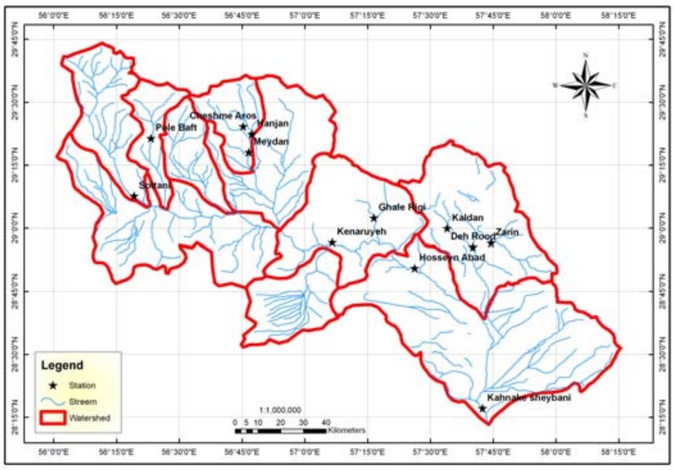

Fig. 2. Location of hydrometric stations in the study area

Peak flow, base time, discharges of 25%, 50% and75% of the peak, time to peak, the times corresponded to discharge of 25%, 50% and 75% that are important component of hydrograph (Snyder, 1938 and Gupta et al, 1986) were selected for developing hydrologic models. These variables were extracted from available hydrographs. Hydrographs were plotted on coordinate system and then dependent variables were extracted. Hydrograph component as dependent variable and physical attributes as independent variables were used for modeling and providing synthetic hydrograph using SPSS software.

Two and multiple regression factor and cluster analysis, were used to determine relationships between dependent and independent variables with the intention of determination and assessment of main factors controlling hydrograph components and also homogeneity of accepted stations. SPSS 13 software was applied for statistical analysis (Esmailian, 2002). Regarding to degree of freedom (n-2), the models which its correlation coefficient were equal or more than 0.250 and 0.325 in 0.01 and 0.05 level respectively were the significant models (Mahdavi, 2002). The Kolmograph- Smironov test was used for normality test. Also homogeneity test for variance of error were used by plotting values of standard error against values of standardized prediction. The accepted points were tested for being monotonous and uniform, and no self correlation test between errors was done using Durbin – Watson test with acceptable values near two. Also analysis of outliers by use of casewise diagnostics test and occurrence of studied values was done within a range of three times of standard deviation (Mozayan, 2003). The regression models were indeed developed from finding direct relations among variables or their changed forms.

Therefore pair relations between variables in states of linear, logarithmic, inverse, two degree, three degree, complex, power, S curve, growth curve and exponential were studied and suitable models related to each of these state were selected (Mozayan, 2003). To determine linear relation between dependent and independent variables, polygonal linear relation test was used (Affifi and Clark, 1995) involving one formula containing relation between one of depended variables with all of independent variables. Factor analyses was used because of high number independent variable (10 variables).

Bartlet test that is current method in many soft ware based on equivalent factors with special value higher than 1 and also explanation variance percentage by used variable for selecting number of factors were used (Sariv stava, 1991).

Varimax and Quartimax for rotation factors were used. Main factors selected by factor analysis were used for multiple variable regressions. Cluster analyses were used by means of sub basins grouping into homogeneity group (Vafakhah, 1999).

Ultimately for selecting suitable model and most effective related independent variables, multiple linear regressions were implemented in three ways: stepwise, back ward and forward methods. Therefore for each of dependent variables one, two or several significant formulas were developed. Then regarding to the freedom degree n-2 and significant level, formula with a significant correlation coefficient were distinguished. For achieving final models of each dependent variable, important assessment criteria such as adjusted coefficient of determination (adjusted R^2), relative error of estimation and approval (RE), root mean square error (RMSE) and finally coefficient of efficiency (CE) were used (Formula 1-3).

$$RMSE = \sqrt{\frac{\sum_{1}^{i=1}\left(Y_o - Y_e\right)^2}{n}} \qquad (1\text{-}3)$$

$$RE = \left|\frac{Yo - Y_e}{Yo}\right| \times 100$$

$$C_E = \frac{\frac{1}{n}\sum_{n}^{i=1}\left(Q_0 - \bar{Q_o}\right)^2 - \frac{1}{n}\sum_{n}^{i=1}\left(Q_o - Q_e\right)^2}{\frac{1}{n}\sum_{n}^{i=1}\left(Q_o - \bar{Q_o}\right)}$$

Where in this formula RE= relative error in percentage, RMSE=root mean square error, Ye=estimated value of dependent variable, Yo=observed value of dependent variable, n=the number of variable, Qo= observed value of discharge, Qe= estimated value of discharge, $\overline{Q}o$ =mean observed value of discharge.

Final selection of derived models were accomplished by less relative error of estimation and approval and root mean square error and more coefficient of efficiency and adjusted coefficient of determination.

3. Results

The main objective of this study was determination of the best relationship between flood hydrograph components and physical characteristics of the basin. With these relationships, the hydrograph components can be calculated using physical characteristics of the catchment. For achieving this objective after determining dependent and independent variables the relationships between these variables were determined by two and multiple variable regression factor and cluster analysis. Evidently in equal condition, the models with more adjusted coefficient of determination, less estimation and approval error and less number of independent variables were selected as the best models. Multiple variable regressions, linear and nonlinear, factor and cluster models were derived using SPSS (Tables 2to4and7to8). In each table the formulas accompanied by adjusted coefficient of determination and correlation coefficient were given. Based on the correlation coefficient, the significant or not significant models were distinguished. Adjusted coefficient of determination showed that how many percentages of dependent variables were explained by independent variables. As it can be seen from the tables, the discharges components with time components have higher adjusted coefficient of determination in terms of meaningful significance, therefore they were better for modeling purpose. From statistical view, the two-variable regression found to be better than other methods, based on its high adjusting coefficient of determination. The ultimate models were chosen from two variable models with higher efficiency coefficient. With attention to adjusted coefficient of determination in two variable regressions (Table 2) it was observed that in formula with more adjusted coefficient of determination, two independent variables including area and perimeter are the most effective for explanation of dependent variables. In linear regression models the adjusted coefficient of determination equal to 0.018 and correlation coefficient equal to 0.26 has the lowest adjusted coefficient of determination that is for T25 (model no.9) and opposite of it the adjusted coefficient of determination equal to 0.135 and correlation coefficient equal to 0.387 has the highest adjusted coefficient of determination that is for Q25 (the model No.47).

Table 2. Results of prevalent two variable regression models

NO	Formula	Adjusted Coefficient of determination (Ad.R.S)	Correlation Coefficient (r)
1	Tp=150.466+(0.207A)+(-4.3E-0.005A2)+(2.14E-0.009A3)	0.046	0.306
2	T50=e(3.985+(-1053/lc))	0.027	0.260
3	Tb=29.164+(0.006A)+(-106E-0.006A2)+(9.11E-0.011A3)	0.067	0.337
4	Tp=-13.904+(4.068Pr)+(-0.014Pr2)+(1.27E-0.005Pr3)	0.048	0.309
5	T25=-29.778+(1.937Pr)+(-0.007Pr2)+(0.06E-0.006PR3)	0.028	0.276
6	Tb=22.3+(0.167Pr)+(-0.001Pr2)+(6.88E-0.007Pr3)	0.067	0.337
7	T50=-77511.3+76125.73G	0.051	0.258
8	T75= e(5.12+(-4.053/lc))	0.045	0.247
9	T25=-73.747+(156.872av.s)+(-34.771av.s2)+(2.174av.s3)	0.018	0.26
10	T25=e(3.479+(-1E+0.033/av.e))	0.019	0.252
11	TP=-29.933+(12.616L)+(-0.11L2)+0	0.065	0.335
12	T25=-29.571+(5.454L)+(-0.045L2)+0	0.027	0.274
13	Tb=20.3+(0.567L)+(-0.006L2)+(1.58E-0.005L3)	0.069	0.340
14	TP=-31.204+(108.137Tc)+(-7.927Tc2)+(0.145Tc3)	0.074	0.347
15	T25=-27. 545+(46.087Tc)+(-3. 358Tc2)+(0.061Tc3)	0.025	0.272
16	T50=23573. 344+3173.918Tc	0.046	0.249
17	T75=3358.087+40192.748log(Tc)	0.04	0.236
18	Tb=22.129+(3.991Tc)+(-3. 36Tc2)+(0.007Tc3)	0.064	0.332
19	Tp=-42. 329+(187.349Tl)+(-23.428Tl2)+(0.752Tl3)	0.075	0.348
20	T25=-33.16+(80. 335Tl)+(-9.96Tl2)+(0. 314Tl3)	0.027	0.275
21	T50=22795.618+5607.924Tl	0.045	0.246
22	Tb=21.598+(7.027Tl)+(-1.012Tl2)+(0.035Tl3)	0.064	0.333
23	TP=e(5.517+(-5.053/Lc))	0.056	0.269
24	T25=15.953+(5.5Lc)+(-0.052Lc2)	0.034	0.257
25	Tb=19471+(1.481Lc)+(-0.043Lc2)+0	0.03	0.280
26	Qp=0.23A0.332	0.119	0.395
27	Q25=0.887A0.332	0.120	0.366
28	Q50=1.784A0.332	0.119	0.365
29	Q75=2.679A0.331	0.119	0.365
30	Qp=e(4.28+(-77.694/Pr))	0.123	0.37
31	Q25=e(2.89+(-77.608/Pr))	0.123	0.371
32	Q50=e(3.587+(-77.691/Pr))	0.123	0.37
33	Q75=e(3.992+(-77.643/Pr))	0.122	0.37
34	Qp=6.562+(2.664G)	0.093	0.329
35	Q25=1.619+(2.682G)	0.095	0.332

Continues of Table 2. Results of prevalent two variable regression models

NO	Formula	Adjusted Coefficient of determination (Ad.R.S)	Correlation Coefficient (r)
36	Q50=3.282+(2.664G)	0.093	0.329
37	Q75=4.927+(2.664G)	0.093	0.329
38	Qp=4E+0.4av.e-0. 387	0.113	0.357
39	Q25=(1E+0.014)av.e-0.389	0.114	0.359
40	Q50=(2E+0.4)av.e-0.387	0.113	0.357
41	Q75=(3E+0.4av.e-0.387	0.113	0.357
42	Qp=e(4.409+(-3.243/Tc))	0.133	0.383
43	Q25=e(3.022+(-3.249/Tc))	0.097	0.385
44	Q50=e(3.716+(-3.242/Tc))	0.133	0.383
45	Q75=e(4.121+(-3.241/Tc))	0.132	0.383
46	Qp=e(4.433+(-2.03/Tl))	0.134	0.385
47	Q25=e(3.046+(-2.034/Tl))	0.135	0.387
48	Q50=e(3.74+(-2.03/Tl))	0.134	0.385
49	Q75=e(4.145+(-2.029/Tl))	0.134	0.385

Table 3 reveals the results of linear regression. This table shows that except the models No.19 and No.20 connected with Tb, the models connected with discharge related to time has more adjusted coefficient of determination, which it corresponds to the results of non curve linear - regression. Three method of stepwise, backward and forward were used by linear regression of which the back ward was more significant. The lowest r^2 is for Tp (model No.13) and the highest r^2 for Tb (model No.19). In linear regression also discharge component has more adjusted R^2 relative to the time component.

Table 3. Results of prevalent linear regression models

NO	Method regression	Formula	Adjusted Coefficient of determination (Ad.R.S)	Correlation Coefficient (r)
1	S	Qp=-0.211A-0.149Pr+0.008G-0.14av.e-0.273L+0.031Pr-0.203Tc-0.206Tl-0.212Lc	0.094	0.331
2	B	Qp=-0.250Tl+0.36av.e-0.274Tc-0.096Lc-0.166L-0.161G+0.06Por-0.22av.s	0.124	0.392
3	F	Qp=-0.211A-0.149Pr+0.008G-0.14av.e-0.273L+0.031Por-0.203Tc+0.206Tl-0.212Lc	0.094	0.331
4	S	Q25=-0.21A-0.14Pr+0.014G-0.14av.e-0.273L+0.039Por-0.202Tc-0.206Tl-0.213Lc	0.096	0.333
5	B	Q25=-0.25Tl+0.037av.e-0.273Tc-0.098Lc-0.168L-0.15G+0.066Por-0.231av.s	0.125	0.393
6	F	Q25=-0.21A-0.149Pr+0.014G-0.14av.e-0.27L+0.039Por-0.202Tc-0.206Tl-0.213Lc	0.096	0.333
7	F	Q50=-0.211A-0.149Pr+0.008G-0.14av.e-0.272L+0.031Por-0.203Tc-0.206Tl-0.212Lc	0.094	0.331
8	B	Q50=-0.25Tl+0.036av.e-0.274Tc-0.096Lc-0.166L-0.161G+0.06Por-0.22av.s	0.124	0.392
9	S	Q50=-0.211A-0.149Pr+0. 08G-0.14av.e-0.272L+0.031Por-0.203Tc-0.206Tl-0.212Lc	0.094	0.331
10	S	Q75=0.71A+0.11Pr+0.072G-0.141av.s+0.052L-0.13Por+0.079Tc+0.081Tl+0.103Lc	0.077	0.296
11	B	Q75=0.013Tl+0.041av.e+0.114av.s+0.012Tc-0.082L-0.002Lc-0.145G+0.144Por	0.130	0.387
12	F	Q75=0.071A+0.11Pr+0.072G-0.141av.s+0.052L-0.13Por+0.079Tc+0.081Tl+0.103Lc	0.077	0.296
13	B	Tp=0.297A- 106.848G36.635av.s +2.4E0.33av.e +7.207L+503.355Por-9.423Tc-11.06Lc +6.525Pr+0.487Qp	0.011	0.419
14	B	T25=0.061A+0.604L+1.067Pr+0.212Qp	0.047	0.333
15	B	T50=76135/730G	0.051	0.258
16	B	T50=0.398Tl+0.415Tc+0.02Qp+0.31G-0.016av.s+0.074Lc-0.048av.e+0.09L+0.185Por-0.964A	0.03	0.214
17	B	T50=-0.068A-0.059Pr +0.031Av.s +0.007av.e +0.027L+0.072Por +0.108Tc+0.099Tl+0.03Lc+0.013Qp	0.051	0.258
18	B	T75=0.365Tl+0.046Qp+0.381Tc+0.324G-0.043av.s+0.068Lc-0.066av.e+0.059L+0.17P-1.226A	0.023	0.198
19	B	Tb=-0.012A+0.0228Pr+1.06E-0.34av.e+0.442L-0.899Lc+0.062Qp	0.255	0.574
20	B	Tb=0.008A+0.148Pr+0.369L-0.752Lc+0.062Qp	0.248	0.557

Factor analysis

Table 4 shows the result of factor analysis accomplished by Varimax and Quartimax. Result of Varimax and Quartimax were quite similar (Table 5).

Because of low correlation coefficient, QP was used accompanied by independent variables in modeling. Variance percentage concerning factors was used for selecting more effecting factors contributed in regression models and arranged in descending method (Table 5). Total variance was calculated by sum of variance concerning independent variable. It is observed by this table, four factor included area, perimeter, Gravelious coefficient and watershed's average slope as main factors covered 98.2 percentage of variance and were used in modeling (Table5). Its concluded that area and perimeter have the most effect on hydrograph component.

Table 4. Result of extracted models by factor analysis

NO	Formula	Adjusted Coefficient of determination (Ad.R.S)	Correlation Coefficient (r)
1	Qp=-0.037A+0.897Pr	0.073	0.323
2	Qp=0.109pr	0.046	0.249
3	Q25=-0.009A+0.224Pr	0.074	0.324
4	Q25=0.027Pr	0.047	0.251
5	Q50=-0.018A+0.448Pr	0.073	0.323
6	Q50=0.054Pr	0.046	0.249
7	Q75=-0.028A+0.673Pr	0.073	0.323
8	Q75=0.082Pr	0.046	0.249
9	Tp=0.653Qp	0.053	0.262
10	Tp=58.726G+0.583Qp	0.051	0.288
11	T25=-0.057A+1.206Pr	0.029	0.248
12	T50=76125.73G	0.051	0.258
13	T75=85139.148G	0.045	0.247
14	Tb=0.001A-0.063Pr+14.744G-0.033av.s +0.063Qp	0.023	0.542
15	Tb=0.001A-0.061Pr+14.696G+0.063Qp	0.243	0.542

Table 5. Results of factor analysis

Variance percentage	Parameter	Precedence	Rotation	Variance percentage	Parameter	Precedence	Rotation
82.099	Area	1	Quartimax	82.099	Area	1	Varimax
8.855	Perimeter	2		8.855	Perimeter	2	
4.343	Gravelious coefficient	3		4.343	Gravelious coefficient	3	
2.897	Watershed's average slope	4		2.897	Watershed's average slope	4	
1.176	Watershed's average elevation	5		1.176	Watershed's average elevation	5	
0.376	Length's of main stream	6		0.376	Length's of main stream	6	
0.158	Pore slope of main stream	7		0.158	Pore slope of main stream	7	
0.094	Tc	8		0.094	Tc	8	
0.002	Tl	9		0.002	Tl	9	
$7.90E^{-05}$	Lc	10		$7.90E^{-05}$	Lc	10	

Cluster analysis

Objective of cluster analysis was obtaining less number of homogeneity groups that included similar stations. Euclid distance that is one of ranking technique and show the homogeneity group in tree's manner (Figure 3) as the best method of cluster analysis were used. Vafakhah (1999) mentioned Euclid distance as the best method of cluster analysis. Tree graph extracted from Euclid distance has shown at figure 3. It is observed by this figure that stations were located at two homogeneity groups. Homogeneity group 1 contained three stations included Meydan , Hanjan and Pole Baft and homogeneity group 2 contained eight stations included Soltani , Koldan, Ghale Rigi, Konaroie, Zarin, Dehrood, Hosein Abad and Kahnakeh sheybani (Table 6). The stations located at one homogeneity group had less distance (Figure 2).

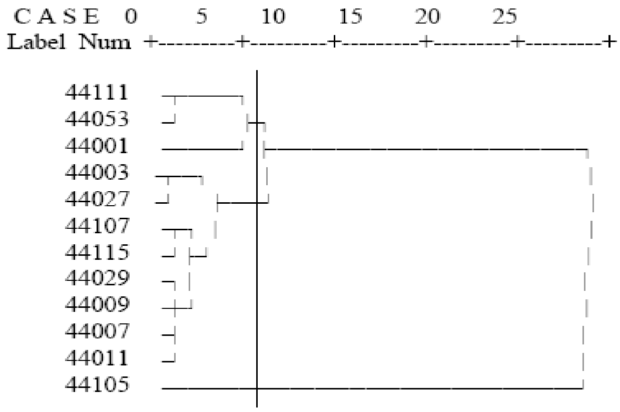

Fig. 3. Tree graph resultant of cluster analysis

Table 6. Result of cluster analysis in the studied stations

Homogene group one			Homogene group two		
Station code	Station Name	River	Station code	Station Name	River
44-111	Meydan	Seyed morteza	44-003	Soltani	Soltani
44-053	Hanjan	Rodar	44-027	Koldan	Rabor
44-001	Poleh Baft	Baft	44-107	Ghaleh Rigi	Ramon
			44-115	Konaroieh	Halil rood
			44-029	Zarin	Saghder
			44-009	Dehrod	Shor
			44-007	Hosein Abad	Halil rood
			44-011	Kahnakeh sheybani	Halil rood

Table 7. Modeling without factor analysis by cluster analysis for homogeneity group 1

No	Formula	(Ad.R.S) Explanation Coefficient	(r) Correlation Coefficients
1	Qp=24.266av.s-2.270Lc	0.066	0.294
2	Qp=23.907av.s	0.002	0.271
3	Q25=5.874av.s	0.000	0.267
4	Q50=11.954av.s	0.002	0.271
5	Q75=17.929av.s	0.002	0.271
6	T25=26.693av.s	0.092	0.396
7	T50=-4189.070Lc	0.047	0.339
8	T75=-5244.324Lc	0.021	0.302

Table 8. Modeling without factor analysis by cluster analysis for homogeneity group 2

No	Formula	Explanation (Ad.R.S) Coefficients	Correlation (r) Coefficients
1	Qp=-3.327L+9.605Tc+5.789Lc	0.096	0.375
2	Qp=-5.781av.s-3.177L+9.285Tc+5.108Lc	0.088	0.384
3	Q25=-0.832L+2.401Tc+1.44Lc	0.096	0.375
4	Q25=-1.445av.s-0.794L+2.321Tc+1.277Lc	0.088	0.384
5	Q50=-1.664L+4.802Tc+2.895Lc	0.096	0.375
6	Q50=-2.89av.s-1.589L+4.642Tc+2.554Lc	0.088	0.384
7	Q75=-2.496L+7.210Tc+4.341Lc	0.096	0.375
8	Q75=-4.336av.s-2.383L+6.970Tc+3.830Lc	0.088	0.384
9	Tp=1.43E-0.032	0.005	0.172
10	T25=-677.244G-36.67av.s+2.97E-0.032-6.833L+64.782Tc	0.086	0.448
11	T50=2935.801Tc	0.023	0.218
12	T75=3094.754Tc	0.015	0.199
13	Tb=1.6E-33av.e-0.206L+1.719Tc	0.105	0.415
14	Tb=-0.001A+1.29E-0.033av.e-0.186L+1.950Tc	0.103	0.439

The Criteria of the coefficient of efficiency (CE), relative error (RE) and root mean square error (RMSE) were used for selection of ultimate models. The higher CE and lesser RMSE and RE indicate the better model. For statistical purpose for each dependent variable only one model that was the best model (having higher more CE and lesser RE and RMSE) were selected (Table 9).

Table 9. Final regression models for estimation of hydrograph component

No	Dependent variable	Formula	Correlation Coefficient (r)	Adjusted Coefficient of determination (Ad.R.S)	Coefficient efficiency (CE)	Residual mean square error (RMSE)	Relative error (RE)
1	Qp	Qp=e(4.28+(-77.694/Pr))	0.37	0.123	0.259	62.52	0.128
2	Q75	Q75=e(3.992+(-77.643/pr))	0. 37	0.122	0.259	62.54	0.128
3	Q50	Q50=e(3.587+(-77.691/Pr))	0.37	0.123	0.259	62.54	0.128
4	Q25	Q25=e(2.89+(-77.608/Pr))	0.371	0.123	0.252	62.42	0.124
5	Tp	Tp=e(5.517+(-5.053/Lc))	0.269	0.056	1.05	33.52	0.004
6	T75	T75=e(5.12+(-4.053/Lc))	0.247	0.045	1.50	27.03	0.27
7	T50	T50=e(3.985+(-1.054/Lc))	0.260	0.027	1.03	29.06	0.29
8	T25	T25=e(3.479+(-1E+0.033/av.e))	0.252	0.022	0.852	23.284	0.07
9	Tb	Tb=21.598+(7.027Tl)+(1.012Tl2)+(0.035Tl3)	0.333	0.064	0.954	23.29	0.01

The relationship of estimated maximum discharge by derived models with perimeter of different stations in studied watershed has shown in Figure 4. It was observed when perimeter increased, the estimated maximum discharge also increased. And these two variables have the same process.

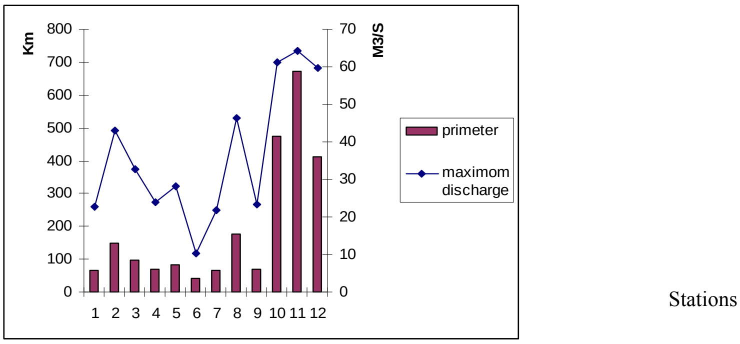

Fig. 4. Relation of perimeter with estimated peak flow

Assessment of developed models was accomplished by graphic method. In this method the observed hydrographs were plotted against the calculated hydrographs. Observed hydrographs were determined by averaging the hydrographs belong to different stations. Falling limb of artificial hydrograph (by use of constant slope of rising and falling limb) were calculted by Snyder method. And then the observed and synthetic hydrographs were compared and assessed as presented in figure 5 to 14.

It is observed that two observed and artificial hydrographs almost have the same shape and indicating importance of modeling for estimation of hydrograph component.

Graphic method was used for the assessment of extracted models by plotting the observed hydrographs against the synthetic hydrographs. Rising limb of synthetic hydrographs were extracted by using models of Table 4 and Falling limb of synthetic hydrograph (rising and falling limb have the constant slope) were extracted by Snyder method. Comparing and assessment of observed and synthetic hydrograph were showed in figures 3-12.

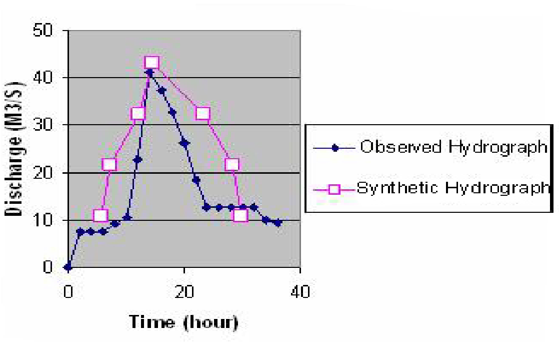

Fig. 5. Observed and estimated hydrograph of Soltani station

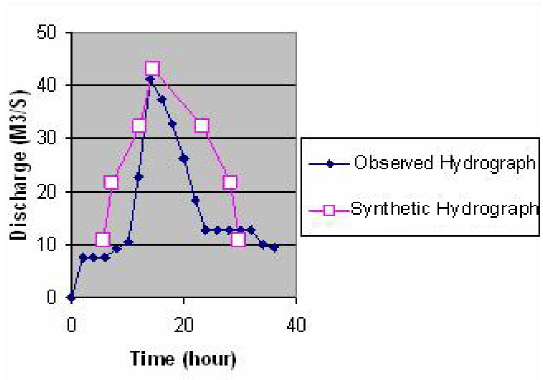

Fig. 6. Observed and estimated hydrograph of Dehrood station

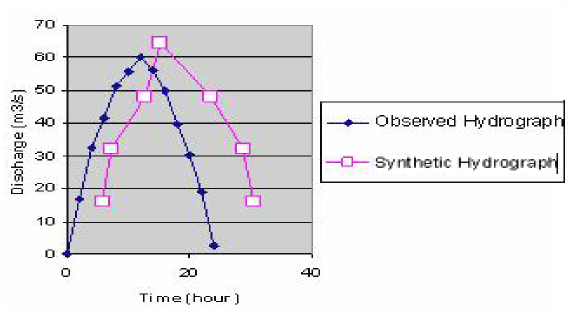

Fig. 7. Observed and estimated hydrograph of Kahnakeh sheybani station

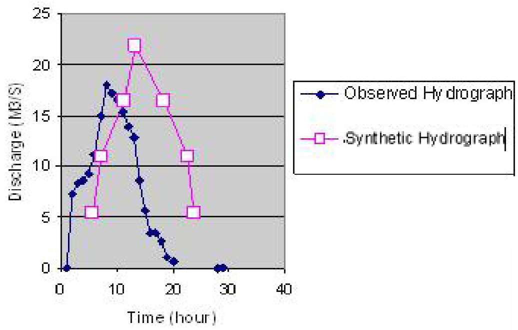

Fig. 8. Observed and estimated hydrograph of Koldan station

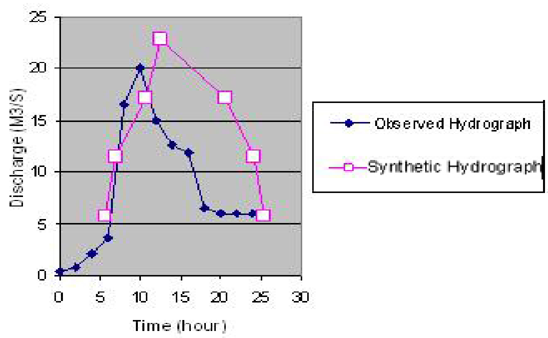

Fig. 9. Observed and estimated hydrograph of Zarin station

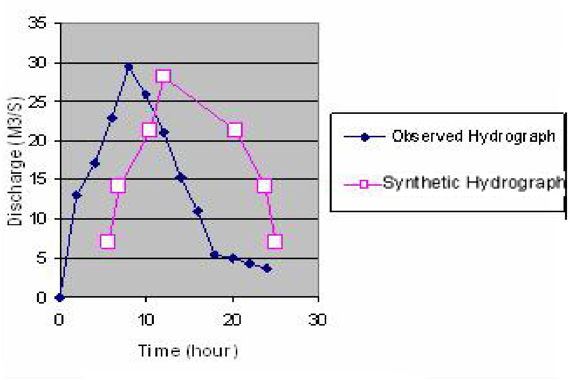

Fig. 10. Observed and estimated hydrograph of Hanjan station

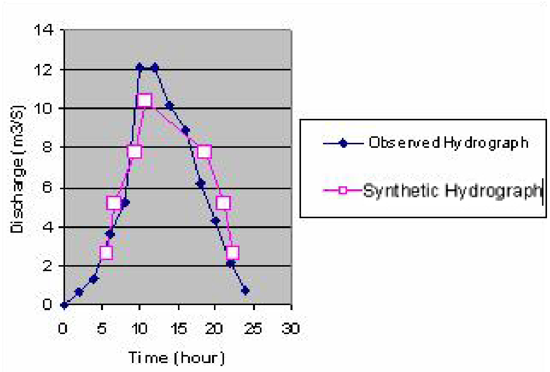

Fig. 11. Observed and estimated hydrograph of Chashmeh Aroos station

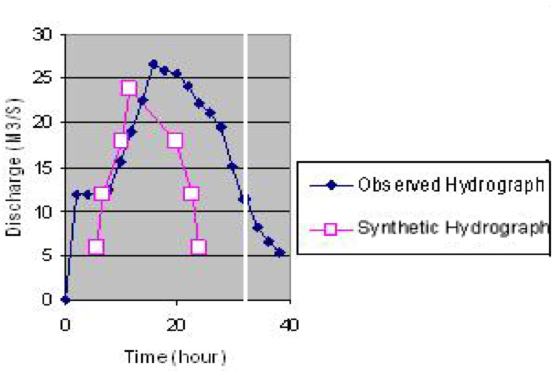

Fig. 12. Observed and estimated hydrograph of Ghaleh Rigi station

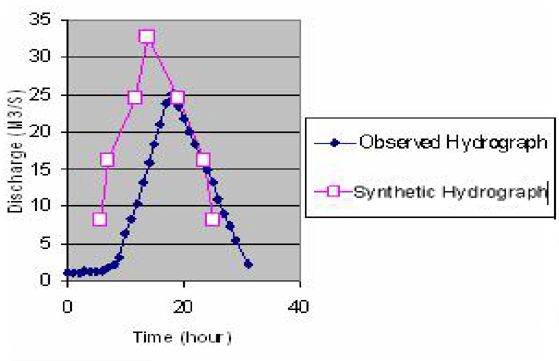

Fig. 13. Observed and estimated hydrograph of Meydan station

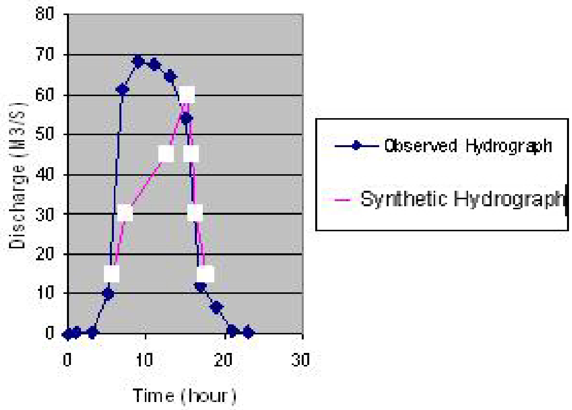

Fig. 14. Observed and estimated hydrograph of Konaroieh station

4. Discussion and Conclusions

Making models for this watershed was relatively hard because of special situation, unsuitable distribution and low rainfall consequently different discharge, unsuitable dispersion of stations and the most important fewer hydrographs compare to other location of the country with better condition. because of lowing variable and quensequently reducing inner relationship and range variable and using one variable for estimation dependent variable, for statistical purpose, two variable regressions was better than multiple regressions (Table 2 and 3). In addition nonlinear relationships for some of two and several variable models for explanation of physical attribute of hydrograph were approved. In which it is corresponded to Singh (1992) based on nonlinear relations of hydrological variable. In total the results based on simulation hydrograph by physical attributes are in agreement with most of last researches (such as Gupta et al., 1986; Yen 1997; Kalian et al., 2003) although estimating variables of different component of hydrograph might be different. Cluster analysis because of better inner relationship for group in which have more stations result in more significant model than one whose group included less stations.in factor analysis as well as two and multiple variable regression area and perimeter have the most important role in modeling that indicate importance of area and perimeter in flooding potential of catchment.

Results of this research based on significant role perimeter and area on controlling maximum discharge of hydrograph is correspond to results of Fuller and Dicken based on following maximum discharge from watersheds area .

The results of accomplished researches in some area of our country (Nekoimehr, 1995; Dindar Hasso, 2000) also denote inability of Snyder model in deriving hydrograph and naturally inefficiency of accepted variables in the mentioned method. by analyzing standardized regression coefficient connected to physical effective factors of watershed in multiple variable formula (Table3) resulted that almost perimeter of watershed have the most controlling role on Q25 , Q50 ,Q75. Area, gravelious coefficient, medium slope of watershed and LC are next controlling factors of mentioned variable.

Also it finded by results of higher two variable regression formula in table 3 that time factors of hydrograph in studied watershed is controlled by LC and lag time. in addition errors of flood hydrograph have high effect on accomplished works and produced unhomogenity condition and unsuitable correlation between dependent and independent variable in which have to taked into consideration.

The difference between these results and former results denoted the necessity of location studies and consideration of controlling variables of hydrograph component. by use of these results mentioned that in spite of very low flood hydrograph for hydrologic analyzing due to scattering data, unmanagment information and also intricacy of governor condition, modeling by these ten factors can be accomplished. Totally it is resulted that possibility of modeling in this watershed and similar areas because of very irregular and unsuitable dispersion rainfall and unhomogenity of location condition related to more damped and with regular rainfall is harder. It should be have more stations and enough frequency of stations for better conditions of modeling.

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