CALIBRATION OF HYDROLOGIC EMPIRICAL METHODS FOR ESTIMATING THE FLOOD PEAK IN THE UROMIA LAKE BASIN IN IRAN

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Abstract: Design flood is a substantial criterion for many water projects. Unfortunately, many of developing countries as well as Iran are faced with lack of sufficient recorded hydrologic data. Thus, in order to cope with data scarcity and study ungauged watersheds, application of developed empirical models based on other gauged catchments is a common strategy used by hydrologists. The present research work is an effort to evaluate a number of ten general empirical models for flood estimation with different return periods, including Dicken, Creager, Gray, Bremner, Waitt, Inglis, Cramer, Murphy, Ocornell, and Cooley Models. Methods were estimating the best coefficient with RSS (Residual Sum of Square) factor in Solver programmer of Microsoft-Excel. The objective data of peak discharge collected and processed with hydrologic statistic models. Objective discharge compare with estimated discharge. The models have been tested in the Uromia Lake basin. In the Uromia Lake basin, all models except the Gray are applicable.
Keywords: Hydrologic Empirical Method, Peak Flood Discharge, Uromia Lake basin, Iran

INTRODUCTION

Determining of hydrologic parameters in safety, economy and functional of hydrologic structures is very important. Thus estimating in hydrology must be precisely for good operations (Afshar, A.1990).
Recently was effected for establishing the hydrometric stations in the watersheds in Iran but some areas due to extent don't have enough equipment for discharge recording. Thus one of the essential problems in watersheds in Iran is determining of runoff and discharge. Empirical models for design often are simplest because understanding, illustration and using them is very easy (Sharifi, M.; Shahidi Pur, M. 2001).
Estimating of coefficient in empirical formula isn't logical. Applying empirical-correlation formulas due to simplify is dominant in city designer. Gary (1982) introduced 35 formulas and Chow (1988) also exhibits some others. Simplest formulas for estimate the flood usually are relations from watershed area. These formulas often are one of the follow shapes:

$$Q_m = cA^n \quad (1)$$

$$Q_m = cA^{(mA^{-n})} \quad (2)$$

$$Q_m = cA/(a + bA)^m + dA \quad (3)$$

Where Qm denotes flood discharge or maximum water discharge, A is watershed surface area In all of these formulas that not show the rainfall and physical factor of watershed area, and a, b, c, d, m, n are regional coefficients that must be determined for region and should be avoid applying these relationships without calibration in engineering designs. In the Gary book exists extent comments about the empirical formulas (Afshar, A. 1990).

Scientists have introduced a lot of formula for compare the floods that all use discharge (Q) and watershed area. Also M. Parde in his searches has tested these formulas in different regions of world.

The goal is finding a simple, easy and universal for hierarchical floods. This action do with a coefficient that is variable but it is enough constant for extant areas. Generally were showed follow:

$$Q = cA \quad (4)$$

$$Q = c'A^{\frac{2}{3}} \quad (5)$$

$$Q = c''A^{\frac{3}{4}} \quad (6)$$

Where: Q=maximum discharge between maximums (m^3/s), A=watershed area (Km^2/s) (Zahedi, M., 1991).

Study area: Iran with 1.65 million Km^2 area is is located between 44^0 2' to 63^0 18' E longitude and 25^0 3' to 39^0 46' N latitude (Figure 1).

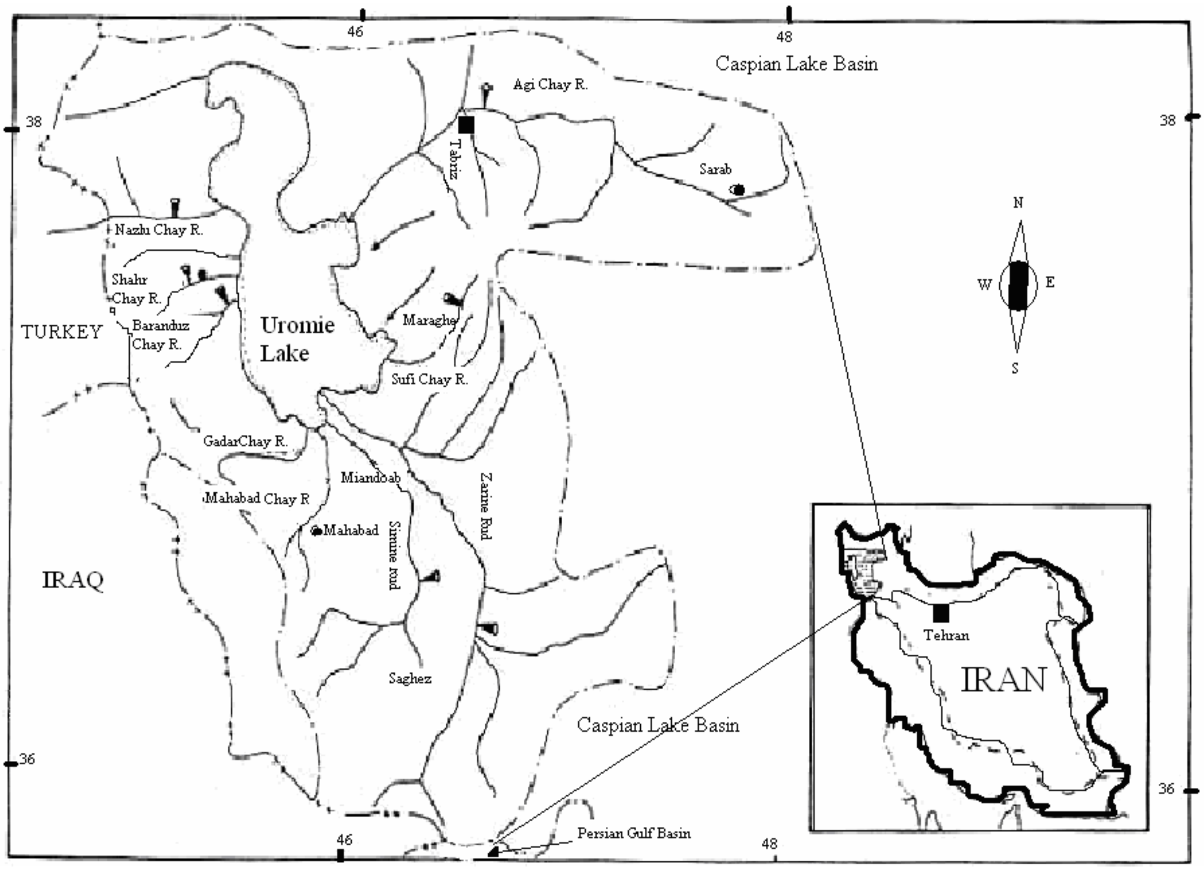

Figure 1 Uromia Lake basin in Iran (Movahed Danesh, A. 1994).

Average annual precipitation in Iran is 256.5 mm. Urumia basin precipitations are both snow and rain. The most discharge is in spring season. The major rivers in this basin are Zarrine Rud, Simine Rud and Ajichay. There are 8 watersheds with area bigger than 1000 Km2 that Zarrine Rud with 7 branches is the biggest. From 1992-93 to 1968-69 the data is not enough and useful. In statistic durations 1969-70 to 1992-93 the data was further for study. 24 years period was considered. Discharges with 2, 5, 10, 25, 50, 100 return periods were applied for calibration procedure (Table 1).

Table 1 Stations, areas and discharges with return periods (2 to 100) (Khalighi Sigarudi, Sh. 1996)

No	Code	Area	Qo2	Qo5	Qo10	Qo25	Qo50	Qo100
1	31-003	45	23.20	31.70	36.9	42.9	47.1	51.2
2	31-015	7432	139.90	224.00	293.9	400.6	494.9	603.3
3	31-031	39	4.40	8.70	12.3	17.9	22.9	28.4
4	31-037	103	16.50	32.00	55.5	111.7	182.3	287.5
5	31-039	290	36.40	65.50	89.4	124.7	154.8	188.1
6	35-003	262	53.10	78.00	101	138.4	172.7	212.9
7	35-005	618	58.00	100.30	147.4	235.5	326.2	442.3
8	35-007	1160	69.20	123.80	180.1	279.2	376.5	496.4
9	35-011	418	74.00	151.50	220.4	328.6	425.4	536.6
10	35-031	1715	69.50	147.70	194.2	271	344.4	434.8

METHODOLOGY

<u>Various shapes of empirical formulas</u>: they were introduced in various countries and regions. There is a list the general shapes of these relations in table 2.

Table 2 General shape of empirical models for estimate peak flood base on watershed area (2=Chow V.T.; David RM.; Lary WM. 1988; 3= Gray, DM 1973; 4= Jafar Zade, S. 1999).

Authors	Country	Comments	General Model	Model
Dicken [2, 3]	India			
Morgan [2, 3]	Scotland	Different area		
Fanning [3]	USA		$Q=aA^b$	M1
Jarvic.C.S. [2, 3]	USA	Extent apply for initial		
Mayer [3]	USA	approximate		
Creager [12, 3]	USA		$Q=46aA^{(bA^c)}$	M2
Gray [3]	Canada		$Q=\frac{aA}{(b+cA)^m}+dA$	M3
Bremner [3]	USA	Small watersheds	$Q=\frac{a}{b+A^c}$	M4
Italian Formula [3]	Italy			
Gangulliet [2]	Switzerland	Switzerland & Italy rivers	$Q=\frac{aA}{b+A^c}$	M5
Waitt-FWF [2, 3]	Australia			

Authors	Country	Comments	General Model	Model
Baird-JM & Mcillwraith-J Mcilluraith & Braid [2] Inglis [2, 3]	Universal Australia India	Maximum estimated flood in the world Maximum recorded storms in Australia Delta region Local rivers	$Q=\frac{aA}{(b+A)^c}$	M6
Cramer [2, 3]	USA	Local rivers Mohavak	$Q=\frac{aA}{b+cA^d}$	M7
Murphy [2, 3] Kuchling [2, 4] Lanter Burg [3] Whistler [2, 3]	USA USA USA Italy	Frequency flood in USA 500< A <15 Km^2 Local apply 1000< A Km 12000< A < 1000 Km Mountain watershed	$Q=(\frac{a}{A+b}+c)A$	M8
Ocornell [2]	USA	Local apply in USA	$Q=a(A+b)^c$	M9
Cooley [2]	USA	For Mississippi River and 10 < T <6 Yr	$Q=a(bA+A)^c$	M10

<u>Best fitting test:</u> There are many methods for selecting the best distributions and relations, but the essential of all them is the same that when different of objective and estimated data were more little that relation is better. The methods for this aim are:

- Mean relative deviation
- Mean square relative deviation
- Residual sum of square (RSS)

RSS formula is:

$$RSS=\left[\frac{\Sigma(Q_e-Q_o)^2}{n-m}\right]^{0.5} \qquad (7)$$

Where: Q_e and Q_o=are estimated and observed flood discharges with a known return period respectively, n=number of record, m=number of parameters in the spatial relation. Each relation that has less RSS that is better and base for estimating flood.

<u>Calculations of coefficients</u>: In solver tools in the Microsoft Excel objective discharges in Uromia basin with 2 to 100 return period and watershed area were inspected and the best coefficient was obtained. Solver is a good program for inspecting and analyzing the data. Formulas that must be numerical value determine as target cell (RSS, Equation 7) in the worksheet and the coefficients set as changing cell. With choosing the cell and giving initial value to changeable cell, Solver changes these cells to arriving the minimum or zero value for target cell. At this time best coefficient was obtained in the changing cells.

RESULTS

The best formulas for the basin: Among the ten considered methods, i.e. M1 to M10 some give reasonable estimating and others produce poor ones. In the peak discharges with T=2 only M3 & M8 had bigger RSS and these aren't suitable.
The peak discharges with T=5 M3, M4 & M2 had bigger RSS and these aren't suitable (Table 3).
With T=10, M3, M4 with biggest RSS aren't suitable.
In T=25, M3, M4, M2 aren't suitable.
In T=50, only M3 had bigger RSS and it isn't suitable.
In the peak discharges with T=100 only M3, M4 & M2 had bigger RSS and these aren't suitable (Table 4).
Generally M8 had less RSS and was the fittest model for the basin.

Table 3 Calibrated coefficients of models and comparing RSS (T=5; return period 5 years)

Models \ Coefficients	a	b	c	d	e	RSS
(M1)	11.5176	0.3379	*	*	*	**27.07**
(M2)	33.0240	-1.5395	-0.1867	*	*	**70.96**
(M3)	23.4863	3.0967	264.1950	3.0426	0.0370	**100.15**
(M4)	70.2564	0.7294	-5.9000	*	*	**75.62**
(M5)	48.9793	64.9952	0.8282	*	*	**24.46**
(M6)	1.5138	1.9851	0.0324	0.8219	*	**26.40**
(M7)	34.7278	149.5713	0.7911	*	*	**24.19**
(M8)	149.1006	245.8285	0.0106	*	*	**23.46**
(M9)	11.5172	0.0049	0.3379	*	*	**28.94**
(M10)	1.6067	339.4180	0.3379	*	*	**28.94**

Table 4 Calibrated coefficients of models and comparing RSS (T=100; return period 100 years)

Models \ Coefficients	a	b	c	d	e	RSS
(M1)	85.3758	0.2792	*	*	*	**743.16**
(M2)	31.2645	-0.2544	-0.1094	*	*	**824.82**
(M3)	11.8693	-29.4850	9.7362	0.0182	-9.5015	**769.39**
(M4)	342.3594	0.5498	-5.9000	*	*	**813.81**
(M5)	510.8866	269.6230	0.9127	*	*	**759.19**
(M6)	219.2396	4776.8169	0.0000	2.4418	*	**680.61**
(M7)	776.5468	680.2711	0.9589	*	*	**759.52**
(M8)	2649.1559	3301.4981	-0.0965	*	*	**751.62**
(M9)	85.4155	-0.2106	0.2791	*	*	**762.46**
(M10)	15.5414	446.0975	0.2792	*	*	**762.46**

CONCLUSION

This method is easy and expand for calibrating the many of models that somebody worked just on one model for example Khalighi, 1996 calibrated only Creager model (M2) for Iran. For estimating the peak flood base on the watershed area in Uromia basin use model number 8 (M8) with new and calibrated coefficient was recommended because generally had less RSS. The models number 2, 3, 4 (M2, M3, M4) shouldn't use because generally had bigger RSS. For example this object was shown better with hierarchical cluster analysis in Figure 3.
M8 formula researched and was introduced from USA and Italy and for areas from 15 to 12000 Km2 had purposed and for mountain watershed had recommended. Also having more parameters can not be a criterion for choosing a good model. For example M3 that has 5 parameters is not a properly model for this basin and has big RSS.

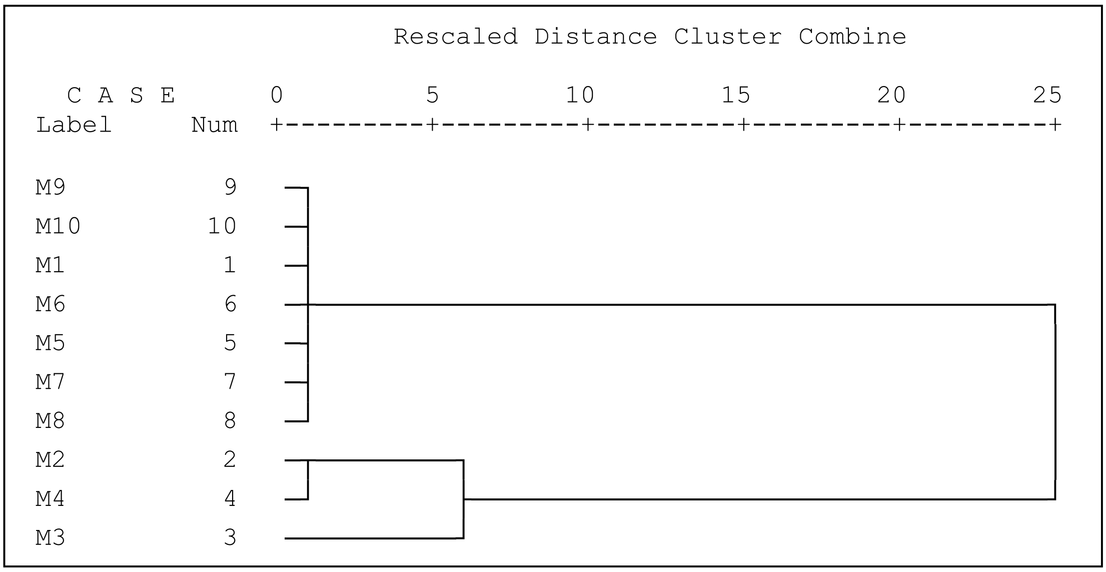

Figure 3 Hierarchical cluster analysis and dendrogram using Average Linkage (Between Groups)

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