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ORIGINAL ARTICLE

Estimation of the Runoff by Empirical Equations in Dry and mid-dry Mountainous area without stations (Case study: Madan Watershed, Qazvin province-Iran)

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ABSTRACT
Determining of surface runoff has main role in many projects such as flood control, erosion and sediment study, artificial feeding plan, dam construction, feeding sub-surface sources, but it is difficult to determine their value because of defect in statistical data and lack of measurement station in watershed. The Madan watershed in Gazvin province is located in dry and mid-dry mountainous area and has little information about runoff. In this research the best method to estimate discharge and landuse was determined using empirical equation of Khuzla, Indian committee for agricultural researches, Cutain, Justin, Lasy with 8 station and satellite imagery of ETM+ 2011 in GIS and ENVI. Results of stations and Lasy equation showed the runoff as 129.60 mm and 152.1 mm, respectively which had 22.50mm (%14.85) difference with stations. This shows its high precision as compared to other methods. According to Lasy equation, it considers many parameters and its estimations are near to observations. So, it can be considered as a tool to manage watersheds of Qazvin province
Keywords: *Lasy, Runoff, GIS, Qazvin province, Dry and mid-dry*

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INTRODUCTION

Human on earth require to healthy water and a humanitarian solution is attempt in providing possibility to access water to drink and agricultural purposes in rural area across the world [18]. This target need to comprehensive and systematic management. The approach to comprehensive and sustainable management of water in scientific society is as the basis of sustainable development in temporal and spatial dimension [21]. The developing of under operation commands based on determined and predicted program to access target without cost and defects or other unpredicted accident is defined as systematic management [25]. But this water was ever affected by flood and pollution. Surface runoff as watershed scale is a process which can be modeled with empirical equations and other methods [20]. Empirical equations were developed to estimate runoff, because there weren't hydrometer stations and statistical defects [10]. The empirical equations of runoff estimation are the relationships and equations which were determined using the investigation of statistical data and properties of the region and are used to estimate especial probability parameters [8]. In spite of the development of empirical equations for estimation of runoff, most of these models had limitations. Many parameters which must be inserted into models require to calibration [7] and all the required parameters of model can not be achieved directly from the watershed [17]. Therefore these equations had problem if the local conditions such as wetter, physiographic and morphology are not considered. Sufficient study should be done and the applicable empirical equation should be selected [6]. Iran have dry and mid-dry climate and traditionally the empirical models are used to hydrology studies and estimation of annual runoff in watershed with dry and mid-dry climate and without hydrometer stations [19]. Results of the test of different methods showed that in regions which are under the drought, Khuzla equation is the most suitable method to estimate runoff. In Madan alamout watershed in Qazvin province there wasn't hydrometer stations and suitable and adequate data. Moreover, the statistical defects of stations cause the runoff estimation in watershed are done using empirical equations such as Khuzla, Indian committee for agricultural researches, Cutain, Justin, Lasy. These are useful and effective tools in managing watersheds of Madan alamout watershed in Qazvin province. Raghunath [16] investigated the relationship among temperature, rainfall and runoff on many watersheds in India and observed the good results to calculate annual water. Negaresh and Hosayni [14] calculated the height of annual runoff with use of the Justin, Indian committee for agricultural researches, and research institute of irrigation in Indian state UP and Lasy equation. Results showed that Justin method showed the better results because of the use of many climatic and non-climatic parameters and regional coefficient in estimating mean annual discharge. Fathzadeh et al. [9] determined the most suitable method of annual estimation in dry and mid-dry regions of Yazd province. Results showed that the equation of the word meteology organization was the best, because it had most correlation with runoff. Abdi et al. [1] determined the most suitable method in determination of annual runoff in Sanij watershed in Yazd province. Akbarpoor et al. [3] in a study about the application of empirical equations of the annual runoff estimation in dry and mid-dry areas showed that the Lasy equation was the better in estimation of annual runoff. Davoodi Rad et al. [8] reported that in large area the Lasy equation have better precision. So, in this research the best method to estimate discharge and landuse was determined using empirical equation.

MATERIALS AND METHODS

The study area in Qazvin province and is a part of central plain of watershed. This region is located between the eastern longitude from 50°32'30'' to 50°42'00'' and northern latitude from 36°18'30'' to 36°24'30''. The extent of watershed in longitude is 9.5 minute and in latitude is 6 minute. The area of the studied watershed Madan almout is equal to 68.12 km^2. The maximum altitude of watershed is 4063 meter and the minimum is 1301 meter (Figure 1).

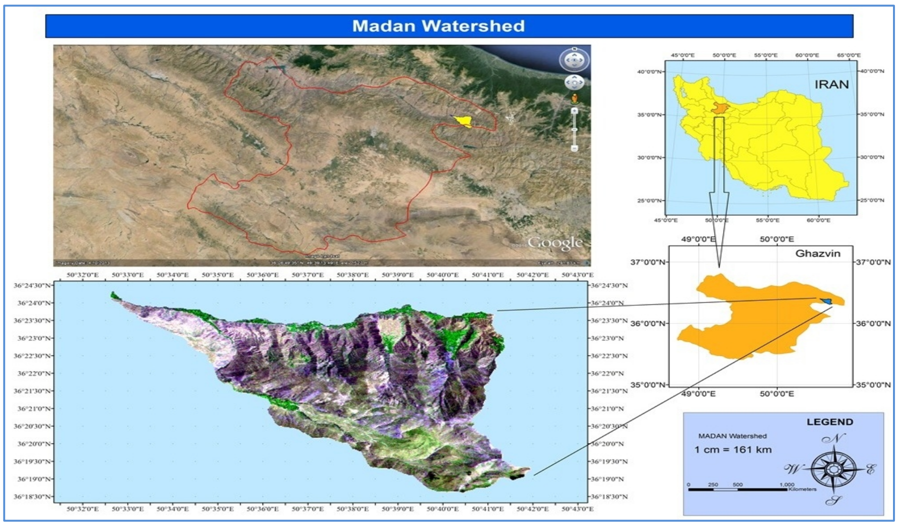

Figure1: Study area

Ten hydrometer stations with statistical duration of 34 years were selected as control to investigate the results of discharge and runoff estimation through mentioned equations (Table 1)

Table 1: Characteristics of hydrometric station

Row	River Name	Stations	Elevation (m)	Latitude	longitude	Area (km^2)
1	Shahrod	Galinak	1770	36° 10´	50° 45´	848
2	Alamut	Baghkelayeh	1350	36° 22´	50° 27´	695
3	Behjatabad	Behjatabad	1400	36° 09´	50° 23´	37
4	Alamut	Siahdasht	970	36° 28´	50° 17´	2445
5	Shor	Polshahabasi	1170	35° 56´	50° 04´	5408
6	Barajin	Barajin	1405	36° 20´	50° 03´	96
7	Hajiarab	Hajiarab	1670	35° 35´	49° 45´	550
8	Kharrod	Rahimabad	1400	35° 52´	49° 33´	4320
9	Ziaran	Ziaran	170	36° 06´	50° 30´	96
10	Hjiarab	Nosratabad	1900	35° 33´	49° 37´	106

Ziaran and Nosratabad stations were not used, because the statistical period was short. Then the correlation of each stations was determined and its statistical defects were corrected (Table 2) and the seasonal runoff in each stations was determined to compare with runoff estimated by equations separately for 34 years in each station as averages (Table 3).

Table 2: The correlation coefficient of hydrometer stations of the region (R%).

Stations	Galinak	Baghkelayeh	Behjatabad	Siahdasht	Polshahabasi	Barajin	Hajiarab	Rahimabad
Galinak	100	86	96.4	70	66.3	48	60	55.7
Baghkelayeh	86	100	96.4	75.5	72.8	41.2	53	54.8
Behjatabad	96.4	96.4	100	86.6	82.5	41.2	72.1	54.8
Siahdasht	70	75.5	86.6	100	94.3	49	87.7	87.2
Polshahabasi	66.3	72.8	82.5	94.3	100	55.7	78.7	80
Barajin	48	41.2	41.2	49	55.7	100	94.9	92.7
Hajiarab	60	53	72.1	87.7	78.7	94.9	100	87.2
Rahimabad	55.7	54.8	54.8	87.2	80	92.7	87.2	100

Table 3: seasonal runoff in each stations (mm)

Stations	Statistical period	Fall	Winter	Spring	summer
Galinak	1958-2011	128.00	136.60	135.40	14.20
Baghkelayeh	1974-2001	162.30	196.80	174.00	22.70
Behjatabad	1978-2011	104.00	109.00	95.70	11.60
Siahdasht	1984-2011	154.10	176.60	1633.80	13.80
Polshahabasi	1977-2011	79.70	88.40	82.50	4.90
Barajin	1977-2011	117.70	133.60	137.30	9.50
Hajiarab	1977-2011	115.10	144.30	113.20	5.70
Rahimabad	1969-2011	168.50	190.20	177.70	21.10
median	34yesr	122.85	140.45	136.35	12.70
Total median		129.60mm			

So, the landuse of study area was determined using satellite imagery ETM+ 2011 and before following application was done:

Geometry correction of satellite imagery

The differences between the shape and dimensions of recorded phenomena in satellite imagery as compared to real size and shape are called as anagram. These biases must be done to observe minimum difference between the image and nature [2]. The precision of the geometry correction depend on the precision of the ground control points and their frequency and dispersal on image. The layer of linear terrain on map such as road and canals was used to correct image.

Radiometer errors

These errors are happened due to atmospheric conditions, elevation of sun and Azimuth during data recording by sensors [2]. The errors of image in initial data and errors of incorrect data which cause to separate image and pixel of nonscanned data were corrected in ENVI software.

Correction of Radiometer errors

A series of errors in satellite image is due to atmospheric dispersal. The satellite data is provided from the energy reflection from objects on earth. These reflections are affected by molecule, water vapor and dust particles and the sent data to sensors is dispersed which cause that recorded image hadn't suitable resolution [14]. Then the mentioned watershed separated to 13 sub watersheds based on their exit point and channel network.

Processing of satellite image

In next stage the best band composition was determined to use in providing false colour image through image observation and suitable limit index (equation 1). Then with the general reorganization of image and different algorithm of image processing in ENVI, each class separately divided from each other using supervised and unsupervised classification methods. Iso data algorithm was used in unsupervised classification [4].

$$I = \sqrt{1 + 2abc - a^2 - b^2 - c^2} \quad (1)$$

a, b, c: correlation coefficient of pair bands

I: classification index which its highest value was the optimum band composition.

Supervised classification method

In supervised classification method of image the values and spectral characteristics of each pixel was compared to pre-determined properties. Therefore we need to information entitled sample area of training area which the coordinate of GPS was determined using 64 points. In this classification method of digital image the classes should not have spectral overlapping, because the separation of terrain can not be done confidence. The samples dispersal especially the means and variance in two dimensional areas must be investigated and corrected using satellite digital image processing softwares.

Therefore the number of considered classes was defined for software and then the software locates them in determined and defined classes according to the spectral properties of phenomena. This method is especially useful to divide disturbed lands. In supervised method the classification operation is done with selecting training areas for each spectral classes and using maximum likelihood algorithm. Indeed the analytical process was used in classification. In this method the mentioned classes in each stage in divided to an especial class with other subclasses. Therefore it is not necessary to use only one algorithm in image classification and it is possible to use especial algorithm with better result in each stage to separate considered class. One of the decision making method about determining of class for each pixel is maximum likelihood which is more precision as compared to other methods. In this method the quantitative levels of variance and correlation of spectral values for different bands is calculated for training areas. This property is used to provide relationship between unsupervised pixels with one of the determined groups. In this method matrix of variance and mean vector is used to investigate the distribution pattern of spectral values and statistical probability for a pixel with one of the groups (Equation 2) [4].

$$P(X/W_i) = \frac{1}{(2\pi)^{\frac{n}{2}}|\sum_i|^{\frac{1}{2}}} \exp\left[-\frac{1}{2}(X-\mu_i)^T \sum_i^{-1} (X-\mu_i)\right] \quad (2)$$

P(X/Wi): the probability of the dependency to class Wi

Σ i: Covariance matrix for class i

μi: mean vector for class i

(x-μi): the vector of difference

T(x-μi): vector of (x-μi) as transmitted from other side of equation.

Khuzla equation

This equation was provided based on the studies in India and USA. In Khuzla equation the mean annual temperature is considered as the factors which affects by the evaporation, transpiration, solar radiation and wind speed on water loss and the equation is as following:

$$R = P - \frac{T}{3.74} \quad (3)$$

Where

R: mean annual runoff in watershed (cm)

P: Mean annual precipitation in watershed (cm)

T: Mean annual temperature in watershed (c).

Equation of Indian committee for agricultural researches (ICAR)

The agricultural researches institute in India recommended the following equation to estimate annual runoff in watershed. The water conservation department in this institute analyzed the 17 sub-basin in Nilgiri Hills state in 1971 and recommended the following equation: Where:

$$R = \frac{1.511P^{1.44}}{T^{1.34}A^{0.0613}} \quad (4)$$

R: annual runoff (cm)

P: annual precipitation (cm)

T: Mean annual temperature (c)

A: The area of watershed (km^2).

Cutain equation

In this method the real evapotranspiration is calculated to achieve runoff rate. This equation is as follow:

$$R = P - D = \lambda P2 \quad (5)$$

D: The shortage of annual follow (m)

P: Mean annual precipitation (m)

R: Mean annual runoff (m)

λ: The following comes from the relationship, the recommended the following equation:

$$\lambda = \frac{1}{0.8 + 0.14T} \qquad (6)$$

T: Mean annual temperature (c).The P must be between the $\frac{1}{2\lambda}$ and $\frac{1}{8\lambda}$ (m).

Lasy equation

Lasy an Indian scientist investigated several watersheds to prepare following equation to estimate annual runoff: Where:

$$R = \frac{P}{1 + \frac{304.8}{P}(Fz)} \qquad (7)$$

Fz: Parameter of rainfall duration and physiographic properties
P: Mean annual precipitation (cm)
R: Mean annual runoff (cm)
Values of Fz coefficient are shown in Table (4).

Table 4: Values of Fz coefficient

Catchment area	Duration rainfall		
	Long	Average	Short
Includes shelf, flat plains with deep soils and vegetation appropriate	6	4	2
Somewhat flattened with deep soils and pasture vegetation.	2.5	1.67	0.83
Relatively high hills with shallow soils and vegetation is relatively weak.	1.5	1	0.5
Sand, gravel and steep terrain with plenty of height	0.88	0.58	0.23
High and steep rocky terrain with no vegetation	0.43	0.28	0.14

According to land type, status of vegetation cover and mean precipitation in region and Table (4) the values of Fz were selected equal to 0.5.

Justin equation

This method is an empirical method to estimate runoff with considering parameters such as mean temperature, slope and precipitation in watershed. The equation is as follow: Where:

$$R = \frac{0.284 * S^{0.155} * P^2}{1.8T + 32} \qquad (8)$$

R: Runoff height (cm)
P: Mean annual precipitation (cm)
T: Mean annual temperature (c)
S: Mean slope of watershed which is equal to

$$S = \frac{H_{max} - H_{min}}{\sqrt{A}} \qquad (9)$$

H: Elevations
A: is the watershed area (km^2)

RESULT AND DISCUSSION

The landuse of the study area was determined using ENVI and GIS (Figure 2) and its precision was determined using Table 5.

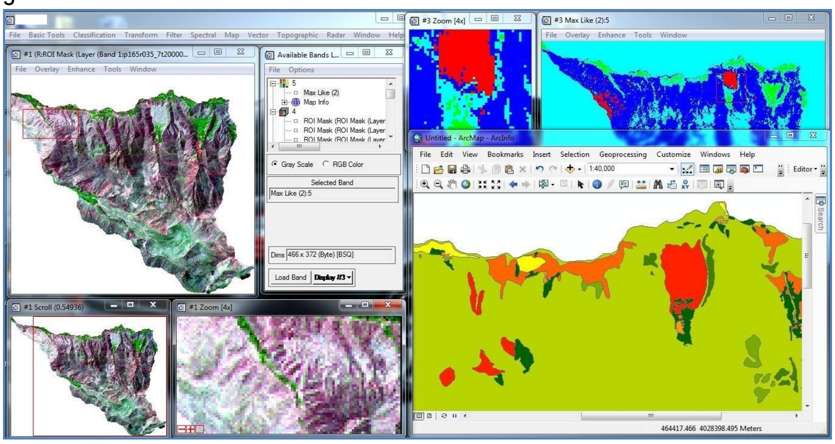

Figure 2: Landuse of the study area was determined using ENVI and GIS

Table 5: landuse of the study area was determined using ENVI and GIS and precision was determined

ETM+2011	
Overall Accuracy	(944/1145) %82.39
Kappa Coefficient	0.74
Class	**precision**
City	4.9
Forest	10.21
Range	42.10
Rock	29.52
Farm	13.27
Total	100

Mentioned equations were used to estimate runoff and discharge which are shown in Tables 6 to 10.

Table 6: Khuzla equation Result

Sub watershed	Area (km2)	Temperature(c)	Average rainfall (cm)	Runoff Elevation (mm)	Runoff volume (1000m3)	Average annual discharge (lit/s)	Runoff coefficient(%)
1	15.75	1.9	72.74	722.3	11376.5	360.7	99.3
2	6.86	4.1	65.23	641.3	4399.6	139.5	98.3
3	7.06	10	45.41	427.4	3017.2	95.7	94.1
4	29.67	4.4	64.5	633.2	18788.1	595.8	98.2
5	1.54	9.9	45.5	428.5	659.9	20.9	94.2
6	2.54	9.3	47.54	450.5	1144.4	36.3	94.8
7	3.95	7.8	52.61	505.2	1995.7	63.3	96.0
8	2.06	10	45.43	427.6	880.8	27.9	94.1
9	5.65	6.6	56.99	552.3	3120.2	98.9	96.9
10	2.34	9.4	47.38	448.7	1049.9	33.3	94.7
11	7	5.5	60.71	592.4	4146.8	131.5	97.6
12	4.74	8.8	49.37	470.2	2228.6	70.7	95.2
13	8.63	11.7	39.47	363.4	3136.3	99.5	92.1
Total	68.12	6.7	56.35	545.6	37165.3	1178.5	96.8

Table 7: Indian committee for agricultural researches equation Result

Sub watershed	Area (km)	Temperature (c)	Average rainfall (cm)	Runoff Elevation (mm)	Runoff volume (1000m3)	Average annual discharge (lit/s)	Runoff coefficient(%)
1	15.75	1.9	72.74	2590.0	40792.0	1293.5	356.1
2	6.86	4.1	65.23	831.1	5701.6	180.8	127.4
3	7.06	10	45.41	149.1	1052.8	33.4	32.8
4	29.67	4.4	64.5	680.1	20177.5	639.8	105.4
5	1.54	9.9	45.5	166.4	256.3	8.1	36.6
6	2.54	9.3	47.54	186.9	474.8	15.1	39.3
7	3.95	7.8	52.61	266.5	1052.5	33.4	50.6
8	2.06	10	45.43	160.9	331.5	10.5	35.4
9	5.65	6.6	56.99	365.9	2067.2	65.5	64.2
10	2.34	9.4	47.38	184.3	431.2	13.7	38.9
11	7	5.5	60.71	505.0	3534.8	112.1	83.2
12	4.74	8.8	49.37	204.6	969.6	30.7	41.4
13	8.63	11.7	39.47	97.5	841.7	26.7	24.7
Total	68.12	6.7	56.35	302.9	20630.3	654.2	53.7

Table 8: Cutain equation Result

Sub watershed	Area (km2)	Temperature (c)	Average rainfall (mm)	$\frac{1}{2\lambda}$	$\frac{1}{8\lambda}$	λ	Runoff Elevation (mm)	Runoff volume (1000m3)	Average annual discharge (lit/s)	Runoff coefficient(%)
1	15.75	1.9	727.4	0.43	0.11	0.87	457.7	7208.9	228.6	62.9
2	6.86	4.1	652.3	0.34	0.09	0.68	290.6	1993.8	63.2	44.6
3	7.06	10	454.1	0.22	0.05	0.44	90.0	635.7	20.2	19.8
4	29.67	4.4	645	0.33	0.08	0.66	276.2	8196.2	259.9	42.8
5	1.54	9.9	455	0.22	0.05	0.44	91.0	140.1	4.4	20.0
6	2.54	9.3	475.4	0.23	0.06	0.46	103.1	261.9	8.3	21.7
7	3.95	7.8	526.1	0.25	0.06	0.50	139.6	551.6	17.5	26.5
8	2.06	10	454.1	0.22	0.05	0.44	90.1	185.7	5.9	19.8
9	5.65	6.6	569.9	0.28	0.07	0.55	179.0	1011.6	32.1	31.4
10	2.34	9.4	473.8	0.23	0.06	0.45	101.8	238.1	7.6	21.5
11	7	5.5	607.1	0.30	0.08	0.60	222.0	1554.2	49.3	36.6
12	4.74	8.8	493.7	0.24	0.06	0.47	114.9	544.5	17.3	23.3
13	8.63	11.7	394.7	0.20	0.05	0.40	61.6	531.8	16.9	15.6
Total	68.12	6.7	563.5	0.27	0.07	0.55	173.7	11832.8	375.2	30.8

Table 9: Lasy equation Result

Sub watershed	Area (km2)	Average rainfall (cm)	Runoff Elevation (mm)	Runoff volume (1000m3)	Average annual discharge (lit/s)	Runoff coefficient (%)
1	15.75	72.74	23.5	3701.5	117.4	32.3
2	6.86	65.23	19.6	1341.2	42.5	30.0
3	7.06	45.41	10.4	736.0	23.3	23.0
4	29.67	64.5	19.2	5690.9	180.5	29.7
5	1.54	45.5	10.5	161.1	5.1	23.0
6	2.54	47.54	11.3	287.1	9.1	23.8
7	3.95	52.61	13.5	533.3	16.9	25.7
8	2.06	45.43	10.4	214.9	6.8	23.0
9	5.65	56.99	15.5	876.4	27.8	27.2
10	2.34	47.38	11.2	262.9	8.3	23.7
11	7	60.71	17.3	1210.6	38.4	28.5
12	4.74	49.37	12.1	572.6	18.2	24.5
13	8.63	39.47	8.1	700.7	22.2	20.6
Total	68.12	56.35	15.2	10361.8	328.6	27.0

Table 10: Justin equation Result

Sub watershed	Area (km2)	Average rainfall (cm)	Temperature(c)	Slope	Runoff Elevation (mm)	Runoff volume (1000m3)	Average annual discharge (lit/s)	Runoff coefficient(%)
1	15.75	72.74	1.9	505.7	111.4	70.70	2.24	153.1
2	6.86	65.23	4.1	506.3	80.6	117.43	3.72	123.5
3	7.06	45.41	10	419.3	29.9	42.30	1.34	65.8
4	29.67	64.5	4.4	494.4	77.4	26.09	0.83	120.0
5	1.54	45.5	9.9	825.2	33.4	217.01	6.88	73.4
6	2.54	47.54	9.3	665.1	36.1	141.99	4.50	75.9
7	3.95	52.61	7.8	715.5	47.3	119.73	3.80	89.9
8	2.06	45.43	10	777.6	32.9	159.67	5.06	72.4
9	5.65	56.99	6.6	763.2	58.8	104.09	3.30	103.2
10	2.34	47.38	9.4	711.2	36.1	154.12	4.89	76.1
11	7	60.71	5.5	751.4	69.7	99.61	3.16	114.8
12	4.74	49.37	8.8	587.0	38.9	82.00	2.60	78.7
13	8.63	39.47	11.7	205.3	19.0	22.05	0.70	48.2
Total	68.12	56.35	6.7	334.6	50.4	7.40	0.23	89.4

CONCLUSIONS

Traditionally the empirical models are used to hydrology studies and estimation of annual runoff in watershed with dry and mid-dry climate and without hydrometer stations. It is difficult to select the suitable method among the different methods of runoff estimation in watershed, because the effective factors on these methods are different from each other. Moreover, the results often show the same results and very different values as compared to control station data. Among different methods, Lasy and Cutain had near results to seasonal runoff, but the precision of Lasy is more than Cutain, because it considers more parameters. Results showed that the variations of discharges in stations of watershed don't follow regular regime. So it is not expected to access accurate results but in the entire world these methods are used especially in hot and dry mountainous areas and in data shortage. The efficiency of these methods depends on accessibility to required data and necessary test. In Madan Almout watershed, empirical methods were used due to the lack of suitable hydrometer stations and high statistical deficiency in estimation of annual runoff. According to Lasy equation (Table 11), it considers many parameters and its estimations are near to observations.

Table 11: Comparison with together formula

Sub watershed	Runoff (mm)					Discharge(m3/s)				
	Justin	Lasy	Cutain	ICAR	Khuzla	Justin	Lasy	Cutain	ICAR	Khuzla
1	1113.6	235.0	457.7	2590	722.3	0.0022	0.12	0.23	1.29	0.36
2	805.6	195.5	290.6	831.1	641.3	0.0037	0.04	0.06	0.18	0.14
3	298.6	104.2	90.0	149.1	427.4	0.0013	0.02	0.02	0.03	0.10
4	774.2	191.8	276.2	680.1	633.2	0.0008	0.18	0.26	0.64	0.60
5	334.2	104.6	91.0	166.4	428.5	0.0069	0.01	0.00	0.01	0.02
6	360.7	113.0	103.1	186.9	450.5	0.0045	0.01	0.01	0.02	0.04
7	472.9	135.0	139.6	266.5	505.2	0.0038	0.02	0.02	0.03	0.06
8	328.9	104.3	90.1	160.9	427.6	0.0051	0.01	0.01	0.01	0.03
9	588.1	155.1	179.0	365.9	552.3	0.0033	0.03	0.03	0.07	0.10
10	360.6	112.4	101.8	184.3	448.7	0.0049	0.01	0.01	0.01	0.03
11	697.2	172.9	222.0	505.0	592.4	0.0032	0.04	0.05	0.11	0.13
12	388.7	120.8	114.9	204.6	470.2	0.0026	0.02	0.02	0.03	0.07
13	190.3	81.2	61.6	97.5	363.4	0.0007	0.02	0.02	0.03	0.10
Total	503.9	152.1	173.7	302.9	545.6	0.0002	0.33	0.38	0.65	1.18

Therefore Lasy was determined as most suitable equation to estimate runoff coefficients (Figure 3).

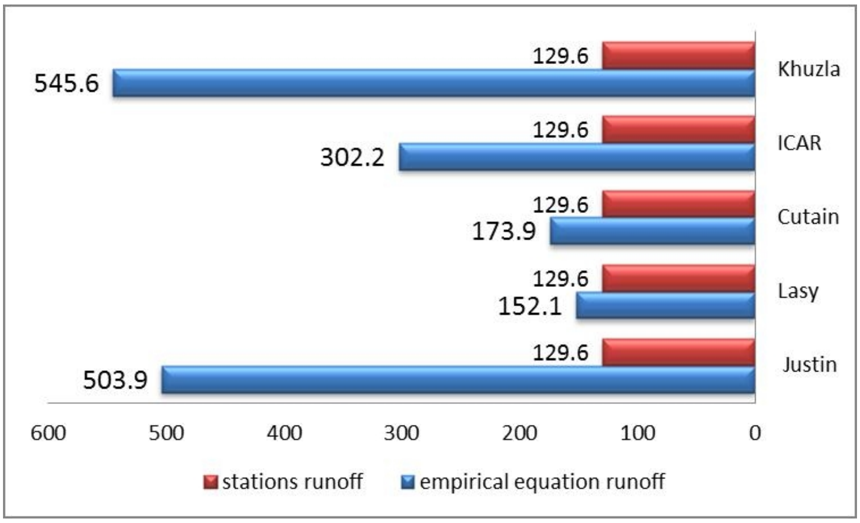

Figure 3: determined suitable equation

This results was in agreement with the findings of Akbarpoor et al. [3] which showed Lasy was the best empirical equation to estimate annual runoff in dry and mid-dry regions and DavoodiRad et al. [8] which reported that in large area the Lasy equation had higher precision. Our results confirmed the findings of Abianeh and Vrkshy [2], Khosroshahi and Saghafi [13], Kalantari and Bazrafkan [11] and recommended that the capability of other empirical equation is assessed in this watershed because of the importance of region for flood, suitable management of water resources and flood control. It is recommended that the methods are calibrated if the empirical methods (Khuzla, Indian committee for agricultural researches, Cutain, Justin, Lasy) are used to estimate runoff in Iran.

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REFERENCES

1. Abdi. M., Fathzad, A., Palyzdan, N. (2009). Experimental methods for determining the best estimate of annual runoff in the watershed lack of statistics in the Dry Areas (Case Study: Yazd Sanychastan watershed). National Conference and drought management strategies. Isfahan., 1(1): 1-7.
2. Abianeh, c., Vrkshy, M. (2011). Assessment of the intelligent neural models and empirical estimates of runoff. Journal of Water and Soil., 25(2): 365-379.20.
3. Akbarpoor , M., Baharlouie, D., Rostami, R. (2006). Using empirical relations that estimate the annual river in arid and semiarid regions. First Regional Conference on Optimum Utilization of Water Resources, Shahrekord University., 1(1): 1-6.
4. Alizade rabii, H. (1999). Remote Sensing (Principles and Practice). University of Tehran press, 304p.
5. Alyari, H., Shekari, F.,and F., . (2000). Oilseed crops. Tabriz Amidi Publications.
6. Asadi. D., Hosaini, M. (2010). Evaluation of experimental methods for estimating runoff in the watersheds in the province of January. The second national conference on agriculture and sustainable development, opportunities and challenges ahead, Shiraz University., 1(1):1-6.
7. Bo X., Hai w., Jun, F., Pang, H. Hau, D. (2011). Application of the SCS-CN model to runoff estimate in an sell watershed with high spatial heterogeneity. Pedosphere, 21(1): 738-749.
8. DavoodiRad, A., Telvari, A., Ghiasi, N. (2005). Comparison and evaluation of empirical relations to estimate the height of the runoff through the continuous evaluation criteria. The second national conference on watershed management and soil and water resources, Kerman., 1(1): 1991-1998.
9. Fathzadeh, A., Fattahi, A., Hezarkhani, N., Shahbazi, M. (2010). The most suitable method for estimating runoff arid and semiarid regions (Case Study: Yazd). Erosion and Sedimentation Conference., 1(1):1-7.
10. Jandaghi, N., Mohammadi. (2009). Comparison with real data on runoff from experimental watersheds Khuzla West province. Watershed of the Fifth National Conference on Science and Engineering, University of Agricultural Sciences and Natural Resources Gorgan., 1(1): 1-9.
11. Kalantari, N., Bazrafkan, M. (2003). Experimental methods for estimating runoff in the Yellow River Basin. Geological Society of Iran Conference., 1(1): 1-11.
12. Karamouz, M., Zahraie, B. (2005). Decision Support System for Monthly Operation of Hydropower Reservoir: A Case Study. journal of Computing in Civil Engineering., 19(2): 194-207.
13. Khosroshahi, m., Saghafi, b. (2003). Participation in Watershed sub-basins of severe flooding in the basin. Research and development 59(1):45-53.
14. Negaresh, H., Hosayni, M. (2011). Estimation method and estimated annual discharge of flood basin razor -Abad city Khas. Journal Research geographical space., 11 (36): 255-282.
15. Prokopy, L. S. (2005). The relationship between participation and project outcomes: evidence from rural water supply projects in India. World Develop., 33(11): 1801–1819.
16. Raghunath, H. M. (2006). Hydrology, principles, analysis, design. 2nd. Ed. New Age International Pub. New Delhi.
17. Terzoudi, C. B., Gemtos, T. A., Danalatos, N. G., Argyrokastritis, I. (2007). Application of an empirical runoff estimation method in central Greece. Soil& Tillage Ressearch., 92(1): 198-212.
18. UN. (2009). The united nations world water development report (3): water in a changing world. UNESCO, Paris and Earthscan, London.
19. Vaisi, Sh., Moazed, H., Panahi, M. (2010). Estimated using empirical relationships in arid and semi-arid river brought annually (Case Study: Watershed premium). Third National Conference on Irrigation and Drainage Networks, Shahid Chamran University., 1(1): 1-6.
20. Voullieme, D., Navarro, P., andMurillo, J. (2012). Influence of mesh structure on 2D full shallow water equation and SCS curve number simulation of runoff event. Journal of Hydrology., 448: 39-59.
21. Warriner, G., James, J., Madden, L., Lukasik, M., Kathleen, M. (1996). Public Participation in Watershed management: A Comprative Analysis. Canadian water Resource Journal., 21(3): 253-273.
22. WHO, UNICEF & WSSCC. (2000). Global water supply and sanitation assessment 2000 Report.
23. World Economic Forum Water Initiative (2009). The bubble is close to bursting: a forecast of the main economic and geopolitical water issues likely to arise in the world during the next two decades. World Economic Forum. http://www.weforum. org/pdf/ water< / WaterInitiativeFutureWaterNeeds.pdf.
24. World Water Council. (2009). Water crisis. <http://www.worldwatercoouncil .org/ index.php?id=25.
25. WWAP (United Nations–World Water Assessment Program). (2009). The United Nations World Water Development Report 3: Water in a Changing World. UNESCO, Paris and Earthscan, London.

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