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CALIBRATING EMPIRICAL EQUATIONS FOR ESTIMATING EVAPOTRANSPIRATION (CASE STUDY: QAZVIN, IRAN)

Saeed Kazemi Mohsenabadi, Mohammad Reza Biglari
Department of Civil Engineering,
College of Engineering Buinzahra Branch, Islamic Azad University
Buinzahra, Iran
s.kazemi@buiniau.ac.ir
biglari.mohammadreza@gmail.com

Abstract— Estimation of evapotranspiration has always been regarded as an important phase of hydrological cycle in different areas. Besids, dominant of this phenomenon in some agriculture and civil domains such as determination of plants water need, designi water canals reveals and estimation of the main part of water loss in dams backside duplicated the importance of this phenomenon and its estimation. The precise Method in estimating evapotranspiration is using lysimetric data, but regarding the lack of this kind of data for regions, experimental equations have been accounted as common Method. in this research, 14 experimental Methods have been used in estimating the potential evapotranspiration of Qazvin. The main goal of this study after comparing the result of empirical equations with pan measured values is presentation of corrective equations using linear regression Method for all equation and evaluation of accuracy of these equations before and after revision. Based on the result of this study, Blaeny-Criddle Method in order to estimate the potential evapotranspiration of Qazvin in Oct, Jul and Jun, and Romanenko Method for Sep and Aug are suggested. Results of the corrective equations showed that using linear regression Method and presentation of corrective equations predominantly increase the accuracy of empirical equations. So that revised Thorenthwait Method with correlation coefficient of 0.988 (R2= 0.988) obtained as the best corrective equation and Jensen-Hais Method was specified as the study area. In addition, after revising this equation and obtained correlation coefficient of 0.868 (R2=0.868), salient decrease of error percentage in all evaluated months has been indicated.

Keywords--**Potential Evapotranspiration, Thorenthwait, Romanenko, Blaeny-Criddle, Corrective Equations, Qazvin.**

I. INTRODUCTION

Evapotranspiration has major applications in agriculture and civil engineering e.g. runoff prediction, designing water canals, estimation of dams water loss, man-made lakes water loss and else. With a rainfall level less than one third of global average (Shakour et al, 2010) and a three time evapotranspiration compared to global average, the disadvantages of this phenomenon is evident more and more in Iran. According to data from Water Resources Organization of Iran, around 70% of the rainfall during 2012 is inaccessible due to evapotranspiration. Moreover, based on the researches conducted by Kazemi, et al (2014) in a 20 years time statistical period in Qazvin, the amount of potential evapotranspiration in the first 8 months of the year was announced as 4.9 times more than of the annually rainfall. Othman, et al (2006) in Fokuawa japan suggested that Thorenthwait result is very close to Fao-penma-monteith Method. In a study conducted by chong-xu et al (2001) in Canada on Rawson and Atikokan lakes comparing the empirical Methods result with pan data indicated the Blaeny-Criddle as the best Method of evapotranspiration estimation in the lakes. In addition revised equations of Blaeny-Criddle, Thorenthwait and Hargreavse-Samani Methods with high correlation coefficient towards pan data was suggested for estimation of evapotranspiration. In southern California, following a study on 4 empirical methods (Turc, Thorenthwait, Makkink, Blaeny-Criddle) and comparing them with Fao-Penman-Monteith as a source, Rao and Castaneda (2005) suggested Turc method as the best empirical relation, however, after equations were revised by linear regression and corrective equations of these relations were provided, results showed that following a revision, all four methods contained a high accuracy ($R^2 \geq 0.90$). Kazemi et al (2014) in a similar and comprehensive research in 16 years time statistical period in Qazvin compared the result of 14 empirical Methods with pan data and concluded that Romanenko and Blaeny-Criddle Methods were the most appropriate ones for annually evapotranspiration computation in the study area.

I. Materials and Methods

A. *Characteristics of the study area*

Airport station is located in Qazvin Plain at longitude 50 degrees and 0.03 minutes east and latitude 36 degrees 15 minutes north and height from sea level to 1279.2 meters. The average annual rainfall (1992-2012) of the station is 323 mm and the amount of evapotranspiration potential in the first 8 months of the year (1992-2012) is 4.9 times the amount of rainfall annually. The average number of frost days during the study period has been recorded 83 days. The average maximum monthly temperature (1997-2012) of August is 35.48 ° C and the average minimum monthly temperature (1997-2012) of February is -3.06° C. The highest average monthly evaporation (1997-2012)recorded is in June with 312.09mm and average minimum monthly evaporation records (1997-2012) in the first eight months of the year is in November with 61.62 mm.

B. Methods

Estimation of evapotranspiration has always been important in hydrological cycle and using lysimeter is the most accurate Method in this estimation, however this Method is time-consuming and costly which is considred as its shortcomings. The most common Method for determining the best empirical equation in aspecific area is using lysimeteric data; however in the loss of this method Fao-pnman-montieth is suggested (Fao 56-1999). Since many of the empirical Methods compute the potential evapotranspiration and there is the lack of lysimetric data for all areas, comparing the empirical Methods output with pan data has been prevalent nowadays. In the first step of this study, by using 14 empirical Methods evapotranspiration for the study area has been computed monthly, in second step, with comparing the output and pan data, the best empirical equation has been suggested for each month. In the third step, by obtaining the corrective equation and correlation coefficient for the equations the best corrective equation and their priorities for usage has been represented. In the fourth step, in order to determine the best Method, relative error obtained from the equation below:

$$Error = \left(\frac{ET_M}{ET_{PAN}} - 1\right) \times 100 \qquad (1)$$

In this equation, Error is that of each method compared to pan data on percent basis, ET_M is the amount of evaluative evapotranspiration using empirical methods on millimeter basis in a month and $\mathbf{ET_{PAN}}$ is the potential evapotranspiration on millimeter in each month. Finally, corrective equations represented in linear regression. In table (I) regional parameter average in a 16 years times statistical period (1996-2012) for the study area is observable.

TABLE I. Regional Parameter Average in 16 Years Times Statistical Period (1996-2012) For The Study Area

Parameter / Month	The Mean Of Maximum Temperature (° C)	The Mean Of Minimum Temperature (° C)	Maximum Possible Sunshine	Actual Sunshine Hours	Percent Relative Humidity	Wind Speed at 2m Height (m/s)	Extraterrestrial Radiation (mm.day)	Maximum Incoming Solar Radiation (mm.day)
April	18.59	5.24	13.15	7.30	53.93	2.58	14.34	11.87
May	24.28	9.34	14.10	8.59	54.87	2.62	15.46	12.68
June	31.22	13.63	14.63	11.16	44.20	2.56	16.77	13.68
July	35.20	17.30	14.40	11.47	42.99	2.58	16.38	12.98
August	35.48	17.88	13.53	11.54	41.00	2.40	15.06	11.82
September	32.26	14.66	12.40	10.71	42.13	2.39	13.00	10.15
October	26.73	10.31	11.28	9.03	45.33	2.24	10.17	7.89
November	17.46	4.88	10.23	6.54	58.08	2.25	7.68	6.25
December	10.29	-0.19	9.68	5.37	63.80	2.25	6.45	5.07
January	5.45	-3.05	9.96	5.20	66.73	2.26	7.00	5.64
February	7.78	-3.06	10.93	5.61	65.93	2.54	9.21	8.21
March	13.64	0.6	11.9	6.63	54.17	2.81	11.75	9.45

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II. Results and Discussion

As it was mentioned before, in this study 14 empirical Methods was used for computing the evapotranspiration which follows as below:

Penman-Fao, Jensen-Hais, Thorenthwait, Linecar, Romanenko, Priestly-Taylor, Turc, Hargreaves-Samani , Irmak 1, Irmak 2, Blaeny-Criddle, Fao-penman-monteith, Makkink, Penman-monteith.

Table (II) shows the result of all these Method and measurement pan data in each month.

TABLE II. Result of all these Method and measurement pan data

Method /Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Penman-Fao	104.8	131	183.1	192.1	182	145.1	89.3	46
Jensen-Hais	292.4	378.1	489.6	530.9	493.7	390.9	254.9	146.5
Thorenthwait	41.2	79.0	143.6	164.2	158.6	114.1	73.7	28.9
Linecar	160.2	199.5	281.5	332.4	344.4	299.6	229.0	142.6
Romanenko	113.0	142.0	225.8	269.5	283.6	244.0	186.4	98.7
Priestly-Taylor	100.7	129.8	182.1	189.4	176.2	133.5	73.1	33.6
Turc	94.2	124.7	183.7	193.2	190.0	156.1	100.5	53.4
Hargreaves-Samani	69.7	147.5	201.7	217.7	200.4	160.4	103.3	54.0
Irmak 1	98.1	120.6	155.8	162.0	156.7	134.2	97.9	58.1
Irmak 2	116.6	135.4	169.6	170.7	160.8	131.9	86.6	53.9
Blaeny-Criddle	135.7	187.0	259.5	295.2	282.9	263.8	158.8	90.9
Fao-Penman-Monteith	109.4	135.2	195.7	213.2	204.4	166.5	107.0	56.9
Makkink	91.1	113.2	151.9	155.1	147.7	122.2	85.8	49.0
Penman-Monteith	106.3	136.1	187.6	208.3	200.9	164.6	110.4	62.4
Pan	82.4	167.0	265.8	312.1	303.3	244.0	157.7	61.6

By using equation (1), relative error was calculated and it can be seen in table (III). By comparing the measured value in table (II) and relative error in table (III), the best monthly results can be obtained. The summary of these result were represented in fig 1 and in table (IV).

TABLE III. Relative Error

Month method	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Error %	Error %	Error %	Error %	Error %	Error %	Error %	Error %
Penman-Fao	27.22	-21.58	-31.09	-38.44	-40.00	-40.53	-43.37	-25.35
Jensen-Hais	254.85	126.39	84.21	70.10	62.74	60.17	61.64	137.76
Thorenthwait	-49.96	-52.70	-45.98	-47.39	-47.72	-53.23	-53.30	-53.07
Linecar	94.40	19.42	5.92	6.49	13.54	22.75	45.19	131.40
Romanenko	37.15	-14.99	-15.03	-13.64	-6.49	0.00	18.17	60.20
Priestly-Taylor	22.26	-22.32	-31.47	-39.30	-41.91	-45.28	-53.63	-45.55
Turc	14.35	-25.35	-30.89	-38.09	-37.36	-36.03	-36.27	-13.36
Hargreaves-Samani	-15.46	-11.72	-24.10	-30.26	-33.95	-34.26	-34.52	-12.37
Irmak 1	19.03	-27.80	-41.37	-48.10	-48.35	-45.01	-37.95	-5.64
Irmak 2	41.55	-18.95	-36.18	-45.32	-47.01	-45.95	-45.09	-12.56
Blaeny-Criddle	64.68	11.97	-2.37	-5.41	-6.74	-2.95	0.71	47.47
Fao-penman-monteith	32.80	-19.06	-26.35	-31.70	-32.62	-31.76	-32.14	-7.70
Makkink	10.51	-32.21	-42.86	-50.30	-51.30	-49.92	-45.63	-20.48
Penman-monteith	29.02	-18.52	-29.41	-33.26	-33.77	-32.55	-30.00	1.27

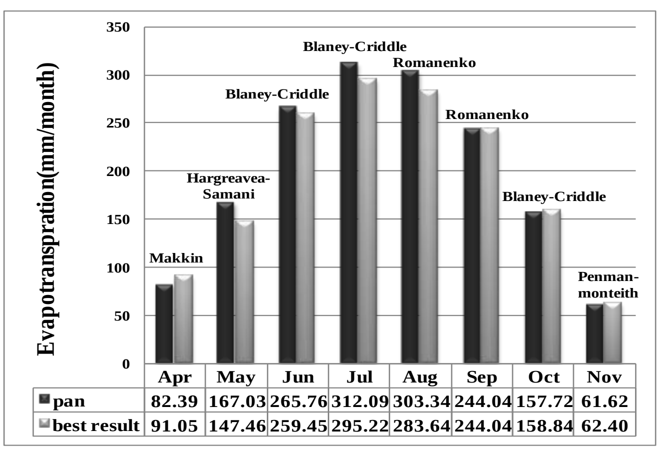


Fig 1 Comparing the Results of the Best Monthly Methods and Pan Data

TABLE IV. Relative Error of the Best Monthly Empirical Method Compared With Pan Data

Month	The Best Method	Percentage Error
Apr	Makkink	10.51
May	Hargreavs-Samani	-11.72
Jun	Blaeny-Criddle	-2.37
Jul	Blaeny-Criddle	-5.41
Aug	Romanenko	-6.49
Sep	Romanenko	0.00
Oct	Blaeny-Criddle	0.71
Nov	Penman-Monteith	-1.27

According to table (IV), in Jun, Jul and Oct, Blaeny-Criddle Method with 2.37, 5.41, 0.71 percent, showed the lowest error respectively and in Aug and Sep Romanenko method with 6.5 and 0 percent represent the best results. Moreover, in Apr, May and Nov with 10.51, 11.72 and 1.27 percent, makkink, Hargreavse-Samani and penman-monteith indicated the closest results comparing with measured values.

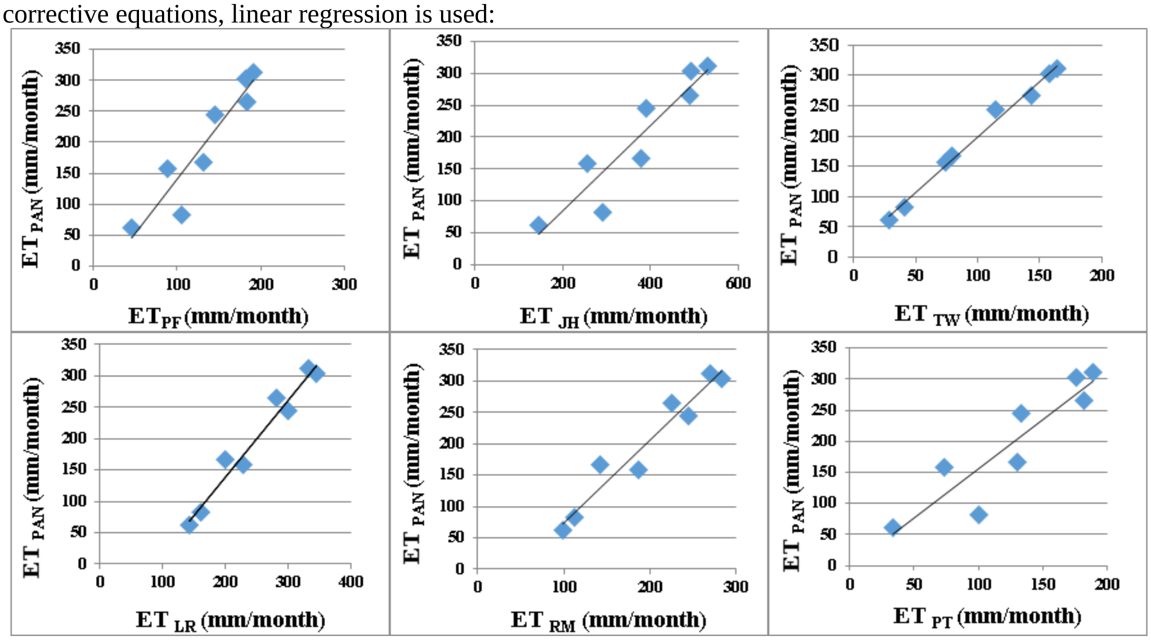
A. Measurement of methods and providing corrective equations

Results from all methods were compared with pan data in former sections. In order to find the relation between pan data and results from empirical methods studied, and provide corrective equations, linear regression is used:

$$Y = mX + c \quad (2)$$

Where, Y is corrective amount of utilized Method, X is empirical methods outputs, m is slope of each diagram and c is the constant representing intercept for any corrective evaluation.

Results from a linear regression analysis to evaluate relation among the amounts obtained by empirical methods and pan data are presented in fig 2. Additionally, in table (VI), corrective equations for all relations, correlation coefficients (R^2) and finally, the priority to use corrective relations are provided. As indicated in table (V), using linear regression Method for evaluating the relationship between empirical Method s with pan data and obtaining corrective equations is an important Method for increasing the accuracy of empirical Methods. For example, according to table (III), Thorenthwait Method in its best monthly result showed 50 percent error but after the revision of this equation with linear regression, revised Thorenthwait Method with correlation coefficient of 0.988 was changed in to the best equation for computing potential evapotranspiration in the area studied and it was also specified better than Methods such as Blaeny-Criddle and Romanenko. Table (VI) indicates of the corrective equations and table (VII) shows the error values of these equations.



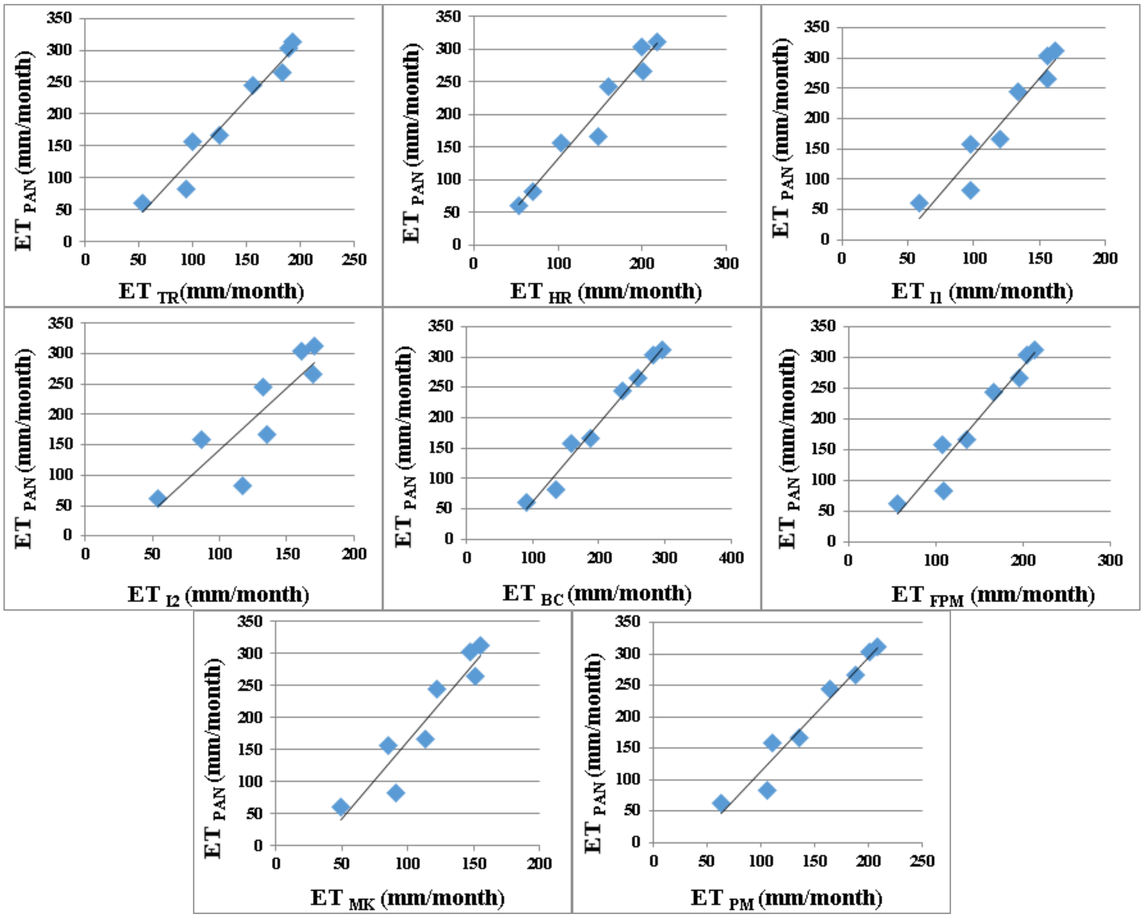


Fig 1. Determination of Corrective Equations Regarding Empirical Method and Pan

Fig 2.

PF= Penman-Fao method; JH= Jensen-hais method; TW = Thornthwaite method; LR= Linacre method; RM= Romanenko method; PT= Priestly-Taylor method; TR= Turc method; HR= Hargreaves-Samani method; I1= Irmak 1 method; I2= Irmak2 method; BC= Blaeny-Criddle method; FPM= Fao-penman-monteith method; MK= Makkink method; PM= Penman-monteith method.

TABLE V. Presentation of corrective equations and correlation coefficients

Priority	Methods	Correction equations	R^2
1	THORNTHWAITE	y = 1.8296x + 15.538	0.988
2	BLANEY-CRIDDLE	y = 1.2905x - 66.408	0.9802
3	LINECAR	y = 1.2274x - 105.93	0.9618
4	HARGREAVES-SAMANI	y = 1.5057x - 18.053	0.954
5	TURC	y = 1.8196x - 49.991	0.9533
6	PENMAN-MONTEITH	y = 1.8148x - 67.663	0.952
7	ROMANENKO	y = 1.3125x - 57.206	0.9355
8	FAO-PENMAN-MONTEITH	y = 1.6786x - 50.089	0.9347
9	IRMAK 1	y = 2.5265x - 111.3	0.9102
10	MAKKINK	y = 2.4159x - 77.362	0.8821
11	PENMAN-FAO	y = 1.7424x - 34.56	0.8744
12	JENSEN-HAISE	y = 0.6733x - 51.295	0.868
13	PRIESTLY-TAYLOR	y = 1.5739x - 1.1306	0.8238
14	IRMAK 2	y = 2.0098x - 58.362	0.7434

TABLE VI. Result Of Corrective Equations

Month / Correction equations	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Penman-Fao	148.07	193.67	284.56	300.21	282.56	218.32	121.06	45.59
Jensen-Hais	145.55	203.31	278.32	306.13	281.08	211.88	120.36	47.35
Thorenthwait	90.97	160.08	278.20	315.96	305.66	224.37	150.29	68.45
Linecar	90.66	138.96	239.56	302.00	316.81	261.76	175.14	69.09
Romanenko	91.11	129.17	239.17	296.55	315.07	263.10	187.42	72.36
Priestly-Taylor	157.41	203.09	285.52	297.04	276.21	113.97	113.97	51.68
Turc	121.44	176.88	284.20	301.60	295.73	234.06	132.91	47.15
Hargreaves-Samani	86.82	203.98	285.68	309.68	283.64	223.52	137.46	63.25
Irmak 1	136.47	193.38	282.40	297.93	284.50	227.76	135.95	35.61
Irmak 2	176.02	213.72	282.50	284.61	264.71	206.76	115.69	49.93
Blaeny-Criddle	108.69	174.94	268.41	314.57	298.69	239.23	138.58	50.86
Fao-penman-monteith	133.57	176.84	278.46	307.72	293.02	229.47	129.58	45.38
Makkink	142.61	196.19	289.49	297.39	279.55	217.91	129.81	41.02
Penman-monteith	125.30	179.31	272.70	310.40	296.89	231.07	132.69	45.58

TABLE VII. Error Of Corrective Equations

Month / Correction equations	Apr Error%	May Error %	Jun Error %	Jul Error %	Aug Error %	Sep Error %	Oct Error %	Nov Error %
Penman-Fao	79.72	15.95	7.07	-3.81	-6.85	-10.54	-23.24	-26.01
Jensen-Hais	76.66	21.72	4.73	-1.91	-7.34	-13.18	-23.69	-23.16
Thorenthwait	10.42	-4.16	4.68	1.24	0.76	-8.06	-4.71	11.08
Linecar	10.04	-16.80	-9.86	-3.23	4.44	7.26	11.05	12.12
Romanenko	10.58	-22.67	-10.01	-4.98	3.87	7.81	18.83	17.43
Priestly-Taylor	91.05	21.59	7.43	-4.82	-8.94	-14.34	-27.74	-16.13
Turc	47.39	5.90	6.94	-3.36	-2.51	-4.09	-15.73	-23.48
Hargreaves-Samani	5.38	22.12	7.49	-0.77	-6.49	-8.41	-12.85	2.65
Irmak 1	65.63	15.77	6.26	-4.54	-6.21	-6.67	-13.80	-42.21
Irmak 2	113.64	27.96	6.30	-8.81	-12.73	-15.28	-26.65	-18.98
Blaeny-Criddle	31.92	4.74	1.00	0.80	-1.53	-1.97	-12.14	-17.46
Fao-penman-monteith	62.12	5.87	4.78	-1.40	-3.40	-5.97	-17.84	-26.36
Makkink	73.09	17.46	8.93	-4.71	-7.84	-10.71	-17.70	-33.44
Penman-monteith	52.09	7.35	2.61	-0.54	-2.13	-5.31	-15.87	-26.03

Tables (VI) and (VII) indicate that using linear regression Method in obtaining corrective equation is an appropriate Method and increases the accuracy of empirical equations. For example, based on table (III), Jensen-Hais Method in Apr with 254.85 percent error, showed the worst result in comparing with other Methods, but after revising this equation, error value for this month reachs 76.66 percent. Besides, after revision error value of this Method in Jul reaches less than 2 percent.

Comparing table (III) and table (VII) indicate that after revision, accuracy of empirical equations does not increase in different months and even after revision decrease of the accuracy is observed, sometimes. For example, after Methods revision, Penman-Fao outputs in Apr, Nov indicate error increase compared with before revision and error decrease in other 6 months which proves the positive application of corrective equations in the most months. But in the case of Jensen-Hais and Thorenthwait Method, after revision no increase error was shown compared with before revision. In order to show the positive impact of equations revision better, by using linear regression Method of Jensen-Hais, Thorenthwait Method compared with pan measured values before and after revision are represented in fig 3, 4.

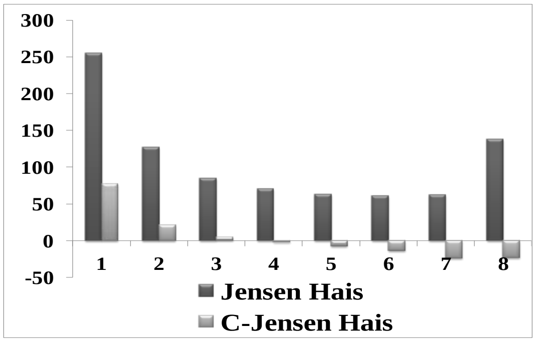


Fig 3. Comparing Jensen-Hais Error Before and After Revision in Comparison with Pan Data in the First 8 Months of the Year

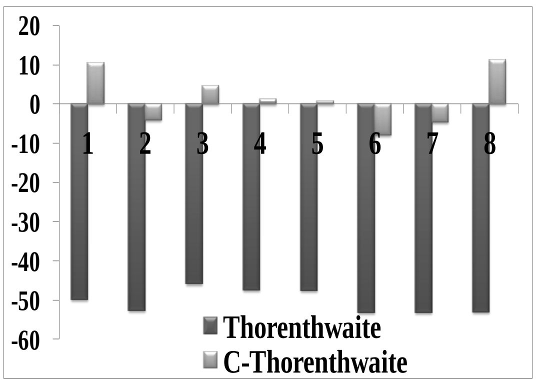


Fig 4. Comparing Thorenthwait Error Before and After Revision in Comparison with Pan Data in the First 8 Months of the Year

As indicated in fig 3, 4, after revision Thorenthwait and Jensen-Hais Method showed increase of accuracy compared with before revision in all evaluated months.

In another analysis of this research, by using tables (VI) and (VII), the best corrective equations for each month can b determined. Table (VIII) represents these equations.

TABLE VIII. The Best Corrective Equation For Each Month

Month	The Best Correction equations	Percentage Error
Apr	Hargreavse-Samani	5.38
May	Thorenthwait	-4.16
Jun	Blaeny-Criddle	1.00
Jul	Penman-monteith	-0.54
Aug	Thorenthwait	0.76
Sep	Blaeny-Criddle	-1.97
Oct	Thorenthwait	-4.71
Nov	Hargreavse-Samani	2.65

As indicated in table (VIII), in May, Aug, Oct, revised Thorenthwait Method has the lowest error with 4.16, 0.76 and 4.71 percent respectively and in Jun and Sep,
revised Blaeny-Criddle Method with 1.00 and 1.97 error percent indicated the best results compared with other corrective equations. Besides, in Apr and Nov, revised Hargreavse-samani Method with 5.38 and 2.65 error percent is the best revised Method and in Jul, revised penman-monteith Method with 0.54 error percent is considered as the best result.

III. Conclusion

- In order to determine the best empirical equation in the loss of lysimetric data, Methods output is compared with pan data to compute the monthly potential evapotranspiration.
- To compute potential evapotranspiration of Qazvin, Romanenko and Blaeny-Criddle Methods represented the best results so that with 0.0 and 0.71 error percent for Sep and Oct respectively has the lowest monthly error compared with other Methods.
- According to table (III), Blaeny-Criddle Method in Jun, Jul, Oct and Romanenko Method in Aug and Sep were suggested as the best Methods in computing monthly potential evapotranspiration. Besides, Makkink, Hargreavse-samani and penman-monteith Methods were suggested as the best Method in estimating potentially evapotranspiration in the area studied in Apr, May and Nov respectively.
- Jensen-Hais Method was the least appropriate Method in computing monthly potential evapotranspiration and it is not suggested to use in Qazvin. However, after revision, this Method showed appropriate results in the most months so revised Jensen-Hais Method with low error percent can be used.
- Revision of empirical equations through linear regression Method and obtaining corrective equations was considered an appropriate Method to increase the accuracy in all empirical Methods.
- Revised Thorenthwait Method with correlation coefficient of 0.988 and revised Irmak Method with correlation coefficient of 0.743 was determined as the best and the worst Method for computing potential evapotranspirationof Qazvin respectively.
- It is suggested to compute monthly evapotranspiration values utilizing corrective equations indicated in table (VIII). By using summation values calculated, annually potential evapotranspiration of the area studied was determined.
- According to the results of the present study shown in tables (IV) and (VIII), it is suggested to estimate monthly evapotranspiration in Apr, May, Jul, Jun and Aug utilizing revised Hargreavse-samani, Thorenthwait, Blaeny-Criddle, penman-monteith Methods and in Sep, Oct and Nov utilizing unrevised empirical equation like Romanenko, Blaeny-Criddle and penman-monteith respectively.

- References

[1] Alizadeh, A. 2010. Principles of Applied Hydrology, Publication Quds Razavi.
[2] Allen, R.G., L.S. Pereira, D. Raes, and S. Martin, 1998. Crop Evapotranspiration. FAO, Rome, pp 297. (FAO, Irrigation and Drainage Paper, 56).
[3] Alkaeed, O., Flores, C., Jinwo, K. and Tautsumi, A., 2006, comparison of several reference evapotranspiration methods for Itsoshima peninsula area, Fukuoka, Japan, J. memoirs of

fculty of engineering, Kyushu university, vol 66, No1.

[4] Asare, D. k., Banini, G. k., Ayeh, E. O. and Amenorpe, G., 2011, estimation of potential evapotranspiration for a coastal savannah environment by comparison of different methods, international journal of sustainable agriculture 3(2):65-70.

[5] C.-y.xu and V. P. singh, 2001, evaluation and generalization of temperature – based methods for calculating evaporation, J. hydrological processes.15,305-319

[6] Irmak. S.a , Irmak. r. g. allenand j. w. jones, 2003, solar and net radiation-based equations to estimate refrence evaporation in humid climates, j. irriation and drainage engineering, Asce, 129(5):336-347.

[7] Castanda, L., Rao, P., 2005, comparison of methods for estimaiting refrence evapotranspiration in sothern California, j. environmental hydrology.

[8] Donald, O., Thomas, C., Donald, C and Gene, E., 2007. Comparison of 15 evaporation methods applied to a small mountain lake in the northeastern USA.j Hydrology, 340, 149– 166

[9] Doorenbos, J., Pruitt, W.O., 1975. Guidelines for predicting crop water requirements. Irrigation and Drainage Paper No. 24, FAO (United Nations), Rome.

[10] Kazemi, S., Biglari, M.R. Moharrampour, M. 2014. The Comparison of Evapotranspiration Different Methods (Case Study: Qazvin Province in Iran). Advances in Environmental Biology, 8(7) May 2014, Pages: 2822-2829.

[11] Kazemi, S., Biglari, M.R. 2014. Determining Best Empirical Relation in Order to Measure Monthly Potential Evapotranspiration of Qazvin in Iran. Advances in Environmental Biology, 8(12) July 2014, Pages: 124-128.

[12] Medeiros, P. V., F. Marcuzzo, F. N., Youlton, C and Wendland, E.,2006, Error Autocorrelation and Liner Regression For Temperature-Based Evapotranspiration Estimates Improvement, J. American Water Resources Association

[13] Roshan, Gh. R., khoshakhlagh, F., Karampour, M., 2012. Assessment and correction of potential evapotranspiration model for Iran, J. Geographical Research of Iran, No 78.