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Evaluating the Best Experimental Method for Estimating Potential Evapotranspiration in Khorasan Razavi, Iran

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ABSTRACT

Estimating potential evapotranspiration based on experimental methods and the temperature parameter is of importance to achieve the best results by the least climatic parameters. The accurate estimate of evapotranspiration based on climatic conditions of each region has a great significance. Taking the physiological and climatic factors into consideration leads to a complicated evapotranspiration calculation process; in this regard, there are several estimating methods. Based on meteorological data, three experimental methods including Blaney–Criddle, Jensen–ayes, and Hargreaves-Samani were applied for weather conditions in Ghochan city, Torbat-e-Heydarieh and Gonabad, Iran. From among the integrated methods, the Cropwat software, based on FAO Penman-Monteith method, was used. In this case, the on FAO Penman-Monteith was considered the reference method to evaluate the accuracy of other methods. According to findings, the Hargreaves–Samani showed the best match with the integrated method data, followed by Blaney–Criddle and Jensen–Hayes methods. Compared to dry weather, Hargreaves–Samani showed a better accuracy in relation to wet weather.

KEYWORDS: Evapotranspiration, Blaney–Criddle, Jensen–Hayes, Hargreaves-Samani, Penman-Monteith.

1. INTRODUCTION

In order to make optimum use of water resources and increase the productivity, water management of crop water requirements consider as a possible way. In this regard, an accurate evaluation of evapotranspiration based on climatic conditions of each region can be mentioned. Considering physiological and climatic factors, we have been led to a complicated evapotranspiration calculation process and hence, several estimating methods (Hargreaves & Samani, 1985). More than 50 methods of estimating reference crop evapotranspiration ETo has been investigated based on experimental, aerodynamics, and combined methods which showed different results according to meteorological data (Dehghani et al., 2004). Examining different methods, FAO suggested Penman-Monteith as the standard method (Alizade et al., 2010). Both direct and indirect (computing) methods are the possible ways of measuring the reference crop evapotranspiration. Lysimeters is the only direct method to evaluate the evapotranspiration. Although the costs of construction, installation, and maintenance have made it difficult to use, the evapotranspiration models is the most reliable method. Climatic and vegetation factors were used as indirect methods and the reference crop evapotranspiration was measured through their relationship with evapotranspiration and equations that have been previously calibrated by direct methods. The simplest method which leads to the actual results is considered desirable scientific method (Erfanian et al., 2009). Based on Liu and et al. (2010), the accurate estimation of evapotranspiration plays an important role in studies such as global climate changes, environmental evolution, and water resource management. Evapotranspiration causes moisture and water loss from the water, soil, and vegetation surfaces and its measurement is of importance through an appropriate method based on the low rainfall and limited water resources in Iran (Shahedi & Zarey, 2011).The appropriate method of determining the ETo depends on each region's climatic condition, its data requirements, and associated costs (Sabziparvar & Shetaee, 2007). Temperature plays the main role in experimental methods and is measured by ambient temperature and potential evapotranspiration (Allen & Pruitt, 1991). American Society of Civil Engineers estimated irrigation water requirements through twenty methods monthly and compared it with the results of the lysimeter. Based on findings, Penman - mantis has the best evaluation (Jensen et al., 1990). Salih and et al. (1983), considered Jensen - Hayes for the calibration of empirical relations in dry areas such as Saudi Arabia. Based on another investigation, Jensen - Hayes and Hargreaves methods were proposed for arid and semiarid climates (Irmark et al., 2003). Entesari and et al. (1996) estimated the potential evapotranspiration through Penman – mantis in some parts of Iran and compared it to some other experimental methods suggested by FAO and analyzed its reliabilities by means of Penman – mantis. Alizade and et al. (2001) evaluated the potential evapotranspiration in Khorasan through Hargreaves – Samani methods; based on their findings, pan evaporation method, despite of being the subject of several climatic data, does

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not show acceptable results for the estimation of potential evapotranspiration. Penman – mantis requires data of radiation, temperature, humidity, and wind speed; since, temperature is the only recorder datain some weather stations it is necessary to examine the level of experimental methods accuracy which required the temperature factor (Asari et al., 2007). Scientific evidences revealed the change in the amount of water plants need; these researches showed a change in the climate system due to the increase in greenhouse gases and consequently the temperature rising (Abasi et al., 2010). According to Mohammadian and et al (2005), the water requirement can be estimated more than 30% due to the effects of dry air in some weather stations. The present paper aims to propose the best experimental method based on temperature in different climatic areas of Khoraan Razavi so that the results find the closest match with the results of the base Penman – mantis method.

2. MATERIALS AND METHODOLOGY

Khorasan Razavi province was selected as the research area. It is located within 33° 52 ' to 37° 42' north latitude and 56° 19 ' to 61° 16' east longitude. In order to investigate the potential evapotranspiration, Ghochan, Gonabab, and Torbat-e-Heydarieh stations were selected due to their long-term climatic data and different weather condition. Collected data from all three stations were analyzed qualitatively. Some data were reconstructed using difference method and mean ratio. Table 1 shows the specification of each station.

Table 1. the specification of used synoptic stations

height above sea level(m)	Latitude	Longitude	station
1287	37° 04' N	58° 30' E	**Ghochan**
1451	35° 16' N	59° 13' E	**Torbat-e-Heydarieh**
1056	34° 21' N	58° 41' E	**Gonabab**

First, the required data for synoptic stations were collected. Statistical period of 15 years was considered as the common statistical period. Then, based on the relations suggested in table 2, the potential evapotranspiration was measured by Blaney-Criddle (1950), Jensen-Haise (1974), and Hargreaves-samani (1985). Using Cropwat software, estimating evapotranspiration was performed through FAO Penman-Monteith method which is approved by most of the researchers.

Table 2. Empirical formula to calculate potential evapotranspiration

formula	method	no
$ET_0 = a + b[P(0.46T + 8.13)]$	Blaney-Criddle	**1**
$ET_0 = C_T(T - T_x)R_s$	Jensen-Haise	**2**
$ET_0 = 0.0023(T_{mean} + 17.8)(T_{max} - T_{min})^{0.5}.R_a$	Hargreaves-samani	**3**

In the case of FAO Penman-Monteith method, the following formula was used in order to estimate the potential evapotranspiration ET_0.

1. $$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma\left[\frac{890}{(T+273)}\right]U_2(e_a - e_d)}{\Delta + \gamma(1 + 0.34\,U_2)}$$

As it was mentioned, the synoptic stations of Ghochan, Gonabab, and Torbat-e-Heydarieh were considered due to their different weather conditions and covering the entire province from north to south. Table 3 shows the climatic specifications of three stations.

Table 3. Climatic specifications of three investigated stations

The annual average					station
Precipitation (mm)	Relative Humidity (%)	Wind speed(Knot)	The minimum temperature(℃)	The maximum temperature(℃)	
313/1	55	3/2	6/3	19/3	**Ghochan**
274/8	46	3/7	7/3	21/3	**Torbat-eHeydarieh**
143/6	37	3/6	10/7	23/8	**Gonabab**

SPSS and Excel soft wares were used for statistical analysis. The following formula was used to calculate the percentage relative error for comparing the experimental method by base method:

2. the percentage relative error $= \left|\frac{\text{base method estimating} - \text{experimenta method estimating}}{\text{base method estimating}}\right| \times 100$

3. RESULTS AND DISCUSSION

Using experimental methods of Blaney–Criddle, Jensen – Hayes, and Hargreaves-Samani, the potential evapotranspiration of Ghochan, Torbat-e-Heydarieh and Gonabad were examined. Then, in order to find the best experimental method, the results were compared to FAO Penman-Monteith method. In this regard the linear correlation method was used. Table 4 shows the findings. High correlation coefficients indicate good agreement among the amountsof evapotranspiration estimated by based method.

This study attempted to rank the different experimental methods. The rank 1 indicates the method with the lowest percentage relative error and highest correlation coefficient and the rank 3 shows the highest relative error and the lowest correlation coefficient. Based on this ranking, the Hargreaves-Samani experimental method achieved the rank 1 and Jensen – Hayes also achieved rank 3. Findings reveled that in the absence of meteorological parameters involved in the formulation of the FAO Penman – mantis, the experimental method of Hargreaves – Samani can show the best result in the case of potential evapotranspiration. Estimating the annual potential evapotranspiration in the Khorasan Razavi indicated that Hargreaves – Samani is the best method in the case of semi-arid to humid regions.

Based on data presented in table 4, the stations have no certain procedure in increase or decrease of the results of experimental methods using the base method.

Table 4. Results of relative error and correlation coefficient using different experimental methods in comparison with the FAO Penman – mantis

Hargreaves-Samani			Jensen – Hayes			Blaney–Criddle			station
Rank	R^2	Relative error (%)	Rank	R^2	Relative error (%)	Rank	R^2	Relative error (%)	
1	0/99	0/84	3	0/76	38/8	2	0/88	22/4	**Ghochan**
1	0/97	7	3	0/72	40/6	2	0/82	32/3	**Torbat-e-Heydarieh**
1	0/94	11/9	3	0/78	36/7	2	0/86	25/6	**Gonabad**

Table 5 also shows regression equations for the three stations.
Using the linear equations, it is possible to estimate the potential evapotranspiration by based method evapotranspiration.

Table 5. Linear regression equations for three studied stations

Hargreaves-Samani	Jensen – Hayes	Blaney–Criddle	station
$y = 5/2714 + 0/9576x$	$y = 4/5645 + 1/3437x$	$y = -5/1928 + 0/8267x$	**Ghochan**
$y = 17/2541 + 0/7914x$	$y = 17 + 1/2089x$	$y = -0/8316 + 0/684x$	**Torbat-e-Heydarieh**
$y = 20/8687 + 0/7313x$	$y = 25/1989 + 1/1853x$	$y = 10/4652 + 0/6686x$	**Gonabad**

4. CONCLUSIONS AND SUGGESTIONS

Based on findings, Hargreaves - Samani is the best method for wet weather conditions in Khorasan Razavi. As we were getting closer from wet regions to dry regions, the estimated data were getting away from the amount of evapotranspiration by FAO Penman – mantis method. Hargreaves – Samani was the best experimental method in Khorasan Razavi. These findings was the same as Alizade and et al. (2001) findings. Other researchers also approved Penman – mantis method and the other methods based on it (Dehghani et al., 2004;Jensen et al., 1990).Based on Zare-abyane (2010), Blaney–Criddle and Hargreaves – Samani were proper methods in the case of 22% of Hamedan province stations. This finding was the same as the present paper too. In all three stations, the lowest potential evapotranspiration was in January and the highest amount was in July. Using the Blaney–Criddle method, results showed that the potential evapotranspiration in Ghochan, Torbat-e-Heydarieh and Gonabad stations were respectively 32.3%, 22.4%, and 25.6% lower than FAO Penman – mantis results; in this regard, the Jensen – Hayes method showed 38.8%, 40.6%, and 36.7% of potential evapotranspiration more than FAO Penman – mantis results. Compared to based method, the Hargreaves – Samani method showed no ranking of the estimations. But, in the case of Ghochan Hargreaves – Samani revealed the potential evapotranspiration 0.84% more than based method and in the case of Torbat-e-Heydarieh and Gonabad stations it were respectively 7% and 11.9% lower than FAO Penman – mantis method.

Finally, considering the average absolute relative error and correlation coefficients for the regression equations in all three stations, the Hargreaves - Samani method, compared to FAO Penman – mantis, could achieve the rank 1 in terms of accuracy in estimating the potential evapotranspiration. Means the results of the mentioned method is approximately the same as FAO Penman – mantis method in the Khorasan Razavi. So, in the case of absence or shortage of data required for using FAO Penman – mantis method in the Khorasan Razavi, the Hargreaves – Samani method can be used to estimate crop water requirement. In order to carry out a proper estimating of potential evapotranspiration in each region, it is suggested that the temperature data record daily so that they can be used in the case of estimating ET0.

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