IN THE NAME OF ALLAH

ESTIMATION OF REFERENCE CROP POTENTIAL EVAPOTRANSPIRATION AND ISO-ETo MAPS FOR IRAN

BY

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To:

My Kind Parents,

brothers and sisters.

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"The best and the most thanks is special for Allah "

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Abstract

Estimation of Reference Crop Potential Evapotranspiration and Iso-ETo Maps for Iran

By

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The increase in world population and the demand for greater food production have placed a heavy burden on arid countries where food production is limited because of climate, environment and technological factors. Management practices for water conservation have been increasingly emphasized because of sparse natural precipitation, high evapotranspiration and excessive depletion of limited groundwater resources. Thus, practical methods for determination of evapotranspiration are essential for optimal utilization of water, especially in irrigation which normally demands the largest share of the available water resources (Alshalan et al., 1987).

There are several empirical methods to estimate ET_0, but still measurement of ET_0 by different types of the lysimeter, gives the most accurate value for it. Several combination methods such as Penman and Penman-Monteith have been presented and are being used all over the world, but it should be noted that some empirical and local

coefficients are used in these equations, which should be calculated for each region (Jensen et al., 1990). Penman and Penman-Monteith methods consist of two major terms: radiation and aerodynamic. In different parts of the world, it has been tried to find the regional coefficients for these two terms.

In the present research, in order to find a relation between solar radiation (Rs) and sunshine duration (n), i.e., in solar radiation equation, values of Rs/Ra and n/N for each month and for 10 stations throughout Iran were calculated. Using a simple linear regression model, Rs/Ra as dependent variable and n/N as independent variable, coefficients "a" and "b" were found for each station. Finally, a unique equation was derived for Iran, using radiation data of 10 stations in the country, as follows :

$$Rs = (0.325 + 0.59 n/N)\, Ra$$
$$R^2 = 0.59$$
St. Err = 0.06
Obs.=490

To find the day-night wind speed ratio for 15 stations in different regions of Iran, firstly their average day time and night time wind speeds (U_d and U_n , respectively) were calculated and then U_d/U_n ratios were obtained for each day and station, using daily data. Finally, averaging these daily ratios for each station, the annual mean values of U_d/U_n for several regions of Iran were calculated. Results indicated that this ratio was higher for the coastal regions, comparing with the other regions. For example, this ratio for Ramsar, Bandar-Abbas and Oroomieh, which are coastal cities, was considerably more than for the

other inland regions. Also, these results showed that this ratio was less for the western regions, comparing with the eastern parts of Iran, and it may be a result of seasonal winds, higher difference between mean monthly maximum and minimum air temperatures, special climatic condition and airmass replacements in these regions.

The $ET_0$41computer program, which was developed by Zand-parsa and Sepaskhah (1996) was used in this research and was modified for solar radiation and U_d/U_n ratio. Using $ET_0$41 computer program, it is possible to calculate ET_0 by FAO Blaney-Criddle, Hargreaves-Samani, Jensen-Haise, FAO corrected Penman and Penman-Monteith methods. In this program, using the information of mean monthly maximum relative humidity, mean monthly relative humidity, mean monthly temperature, mean monthly maximum temperature, wind speed at 2m height, sunshine hours, ratio of U_d/U_n and the elevation of the station from sea level, for each month of each year, the mean monthly and annual values of ET_0 by the five mentioned methods were calculated. In order to plot the iso-ETo line maps for Iran, the Surfer and Autocad 14 softwares were used, and the plots of iso-ETo lines for mean monthly and annual values were presented.

In the present research, the results of the FAO-Penman and Penman-Monteith methods were used to develop new equations, similar to the Hargreaves-Samani equation (HS) in two different forms. To modify the HS equation, non-linear multiple regression was used. In this regression the results of the FAO-Penman and Penman-Monteith methods, seperately, were used as dependent variables and extra-terrestrial radiation, difference between mean monthly maximum and minimum air temperatures and mean monthly

air temperature as independent variables (form 1) and extra-terrestrial radiation, altitude of the station and mean monthly air temperature as independent variables (form 2). Therefore, four equations were developed, as follows:

$$ET_0\ 1_{FAO\text{-}Penman} = EXP(-6.47)Ra^{0.95}TD^{0.2}(T+25)^{1.36}$$

$$R^2=0.87$$

$$ET_0\ 2_{FAO\text{-}Penman} = EXP(-6.72)Ra^{0.88}(EL+25)^{0.04}(T+25)^{1.56}$$

$$R^2= 0.87$$

$$ET_0\ 1_{Penman\text{-}Monteith} = EXP(-7.53)Ra^{0.97}TD^{0.24}(T+25)^{1.6}$$

$$R^2=0.86$$

$$ET_0\ 2_{Penman\text{-}Monteith} = EXP(-7.88)Ra^{0.86}(EL+25)^{0.05}(T+25)^{1.82}$$

$$R^2=0.86$$

The mean annual ET_0 from the several mentioned methods of estimation was plotted and compared with Penman-FAO method. Results showed that in the regions with low annual ET_0 (<1400 mm/year), FAO Blaney-Criddle method has estimated the largest values and Jensen-Haise method has estimated the lowest values. In the regions with the intermediate ET_0 (1400-2000 mm/year), Jensen-Haise method estimated the largest ET_0 and the Hargreaves-Samani method estimated the least. Penman-Monteith method estimated the closest value to that of Penman-FAO, although less than it.

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