A CASE STUDY TO EVALUATE THE EVAPOTRANSPIRATION METHODS

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ABSTRACT

Precise estimation of evapotranspiration is an important step in the field of water resource management, it varies spatially and temporally. Recently, the Food and Agricultural Organization (FAO) has suggested FAO-56 Penman Monteith method (modified PM method) as a standard method for calculating evapotranspiration (ET_o), because this method is applicable to all type of seasons and different climates and gives more precise results when compared with physical methods such asLysimeter and Class A pan. FAO-56 PM method cannot be debated by any other methods which require less data for calculating ET_o but FAO-56 PM requires huge meteorological data, which is not available at full climate stations. So there is need to find out another suitable method after FAO-56 PM, which will givecloserET_o results. Here six different methods are considered for present study, which are radiation based (FAO-56 Hargreaves, Turc, Priestley-Taylor), temperature based (Thornthwaite, Blaney-Criddle) and combine parameters based (FAO-56 modified Penman Monteith method).

The goal of an effective scheduling is to supply the plants with sufficient water while minimizing loss to deep percolation or run-off. Estimation of accurate irrigation scheduling is very much required for proper management of water as per the requirements and to minimize the water losses. Proper scheduling is plotted for the crops coming under that area considering all the parameters related to it. Main motive of irrigation scheduling of this area is to generate awareness in farmers regarding water use to obtain maximum yield of crops.

KEYWORDS: Evapotranspiration, Crop water requirements, Irrigation scheduling.

1. INTRODUCTION

In a cropped field, water can be lost through two individual processes from the soil surface and wet vegetation, this process is called as evaporation. The grouping of two different processes in which water is lost by evaporation from the soil surface and by transpiration from a plant, is called evapotranspiration (ET). Evaporation and transpiration occur at the same time and there is no easy way to distinguish between the two processes.

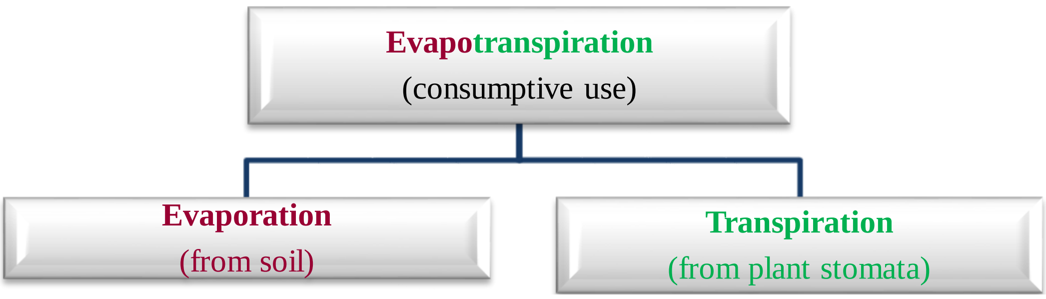

Figure 1– Combine process of evaporation and transpiration results in evapotranspiration.

When the height of crop is small then evaporation is the main process, because more portion of soil surface is exposed to sun, but once the crop is totally grown and completely covering the ground, then transpiration becomes more leading process. It is assessed that at the crop sowing stage, 100% of the total ET comes from evaporation process, while at the stage of fully grown crop which iscompletely shading the ground, evaporation process is about 10% of complete evapotranspiration process and remaining 90% is transpiration.

1.1 Factors affecting crop evapotranspiration

Climatic parameters, crop management practices,crop characteristics and environmental aspects are the main factors affecting evapotranspiration process.The main climatic factors affecting evapotranspiration are solar radiation, air humidity, air temperature and wind speed. During the summer season, rate of evapotranspiration is more as compared to winter and rainy season. This is because solar radiation and temperature are higher in summer season.

The crop type, variety and development stages also affect evapotranspiration process. Crop height, reflection,crop roughness, canopy cover and crop rooting characteristics result in different evapotranspiration levelsunder indistinguishable environmental conditions in different types of crops.

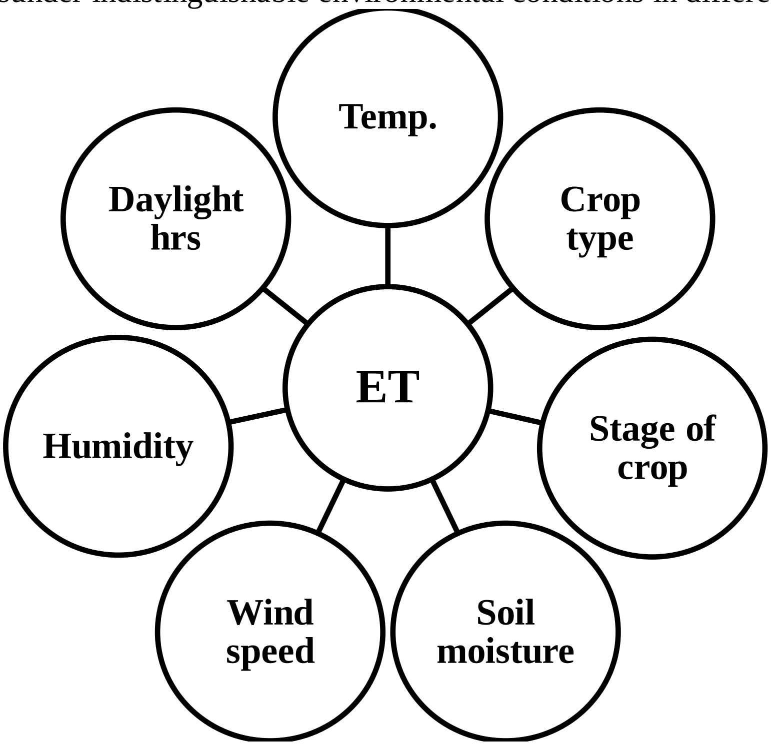

Figure 2 – Factors affecting ET.

Factors such as soil salinity,limited use of fertilizers, poor fertility of land in addition to chemicals, lack of pest and disease control, poor soil management and limited water availability at the root zone may bound the crop development and diminish evapotranspiration process. Other factors that affect evapotranspiration are plant densityandgroundcover. Cultivation practices and the type of irrigation system used can change the microclimate, affect the crop characteristics. All these are the factors which affect evapotranspiration process.

1.2 Soil water factors

According to FAO (1992), if plants are sufficiently anchored and there are appropriate growing conditions (available water and nutrients, soil aeration, etc.), the ET_c is not affected, when rooting depth is severely restricted. However, the following conditions must be considered:

a. Available soil water
b. Groundwater
c. Salinity
d. Water and crop yield

1.3 Irrigation scheduling

Parameters to be considered in preparing an irrigation schedule are as:

a. The daily crop water requirements
b. The soil, water-holding capacity or particularly its total available moisture
c. The effective depth of root zone

Plant response to irrigation is subjective by the physical condition, fertility and biological status of the soil. Soil condition, structure,texture, depth, organic matter, bulk density, acidity,salinity, drainage, topography, chemical characteristics and fertility all affect the level to which a plant root system penetrates into and uses available nutrients and moisture in the soil. Many of these factors impact the water movement in the soil, the water-holding capacity of the soil, and the ability of the plants to use the water. The irrigation system used should match all of these conditions.

2. OBJECTIVES

1. To estimate monthly ETo values by all the methods and their comparison with standard FAO-56 Penman Monteith method to find best alternate method after it.
2. To calculate the crop water requirements using accurate ETo for each crop.

3. CASE STUDY

Chaskaman dam and its left bank canal is selected for this study. The objective of this study is to calculate daily, seasonally, annually reference ET_o using all methods for 'left bank canal of Chaskaman and its command area'. Comparative study of five methods on periodic basis showed that PT method yielded highest R^2=0.92 and BC method yielded lowest error values as 1.33 for percent deviation and 0.08 for Standard Errors of Estimation(SEE). Comparison on seasonal scale showed that, for summer season BC method is the best which yielded lowest error values hence it ranked as the best after FAO-56. For rainy and winter season, on the basis of errors estimation PT method performed best among all methods and yielded values close to that of FAO-56 PM method. Further ET_c (crop evapotranspiration/ crop water requirements) will be calculated for that command area. With reference to crop pattern, an Irrigation requirement is calculated, followed by Irrigation scheduling. The goal of an effective Irrigation scheduling is to supply the sufficient water to the plants while minimizing deep percolation loss or run-off.

The Chas Kaman Dam of Maharashtrais one of the important dams and is built on the BhimaRiver at Rajgurunagar in Pune district. The Chas Kaman Dam is the earthen dam which is about 738 meters in length and the masonry dam of 220 meters length. The maximum height of the dam from its lowest foundation level is around 46 meters. The dam has five radial gates with a spillway of around 72 meters. The depth of the dam is about 150 meters.The reservoir holds about 241 MCM of water of which 214 MCM is approved for use for irrigation purpose.

It is estimated that this dam can irrigate about 32824 ha of land from the villages nearby. The dam directly give benefits to the large number of villages in the Pune district. The dam and the surrounding areas receive rainfall from southwest monsoon from the month of June to September.

4. COMPARATIVE STUDY OF REFERENCE EVAPOTRANSPIRATION METHODS

Evapotranspiration values by all five methods are calculated and are compared with FAO-56 PM Method. This study is completed to find out the alternate best method for Chaskaman command area after FAO-56 PM method. So as to find out the results, calculated values are divided on monthly, seasonally and yearly basis. Their regression equations are calculated and error estimation is also done with the help of SEE, percent Deviation and ARE.

Daily values of ET_o are calculated first, then this values are converted into monthly values. Average monthly values of $ET_o$are tabulated in table 1. Yearly values are estimated from monthly ET_o values and are listed further. Graphical representation of monthly values of ET_o is shown in figure 3. The graph showed that values of ET_o goes on increasing from month of January-May. This is just because there is increase in the temperature up to month of May. Then from May-December, the value goes on decreasing as the temperature goes on decreasing. Regression analysis graph of five methods compared with FAO-56 PM method are also shown in further section.

4.1 Monthly Basis–

In comparative calculation by regression and error analysis, results indicated that Priestley Taylor method gave high coefficient of determination value (R^2 = 0.9298) and lowest ARE (0.1471). After that Blaney-Criddle method showed the lowest errors such as 1.33 and 0.08 for percent deviation and SEE. Turc method found to be closely following Priestley Taylor method having high R^2 value as 0.91 and 0.30, 0.21, 0.93 for ARE, percentage deviation and SEE. Hargreaves method also performed well after Turc, showing values 0.90, 0.15, 12.12 and 0.69 for R^2, ARE, percent deviation and SEE respectively.

Here more weightage is given to the results from error analysis in present study since the coefficient of correlation (R^2) in regression analysis is only an indicator of how well the line of regression fits with the original data and do not consider the actual closeness/ error of each estimated record with respect to actual standard record. Hargreaves method also follows Priestley Taylor method closely in error as well as regression analysis. But as HR method requires less data than Priestley Taylor method, it has given third rank. Turc and Thornthwaite performed low in ARE, Percent deviation as well as SEE, so their rank is low. The comparison calculation of all methods is shown in table no- 2.

Table 1– Monthly average ET_o values by all methods:

Methods/Months	January	February	March	April	May	June	July	August	September	October	November	December
FAO-56 PM	3.59	5.11	6.81	8.88	9.29	5.77	4.07	3.61	3.88	4.13	3.56	3.18
PT	3.18	4.11	4.86	5.49	5.70	4.46	3.82	3.57	4.08	4.08	3.58	3.09
BC	4.41	5.73	7.09	7.864	8.24	4.77	3.37	2.88	3.41	4.44	4.43	4.31
TC	5.12	5.62	6.38	7.04	6.58	5.64	5.26	5.14	5.40	5.61	5.43	5.13
TH	3.71	3.93	4.25	4.58	4.69	4.49	4.30	4.17	4.13	4.10	3.90	3.93
HR	3.74	4.71	5.4	6.18	6.2	4.36	3.54	3.28	3.94	4.40	4.13	3.68

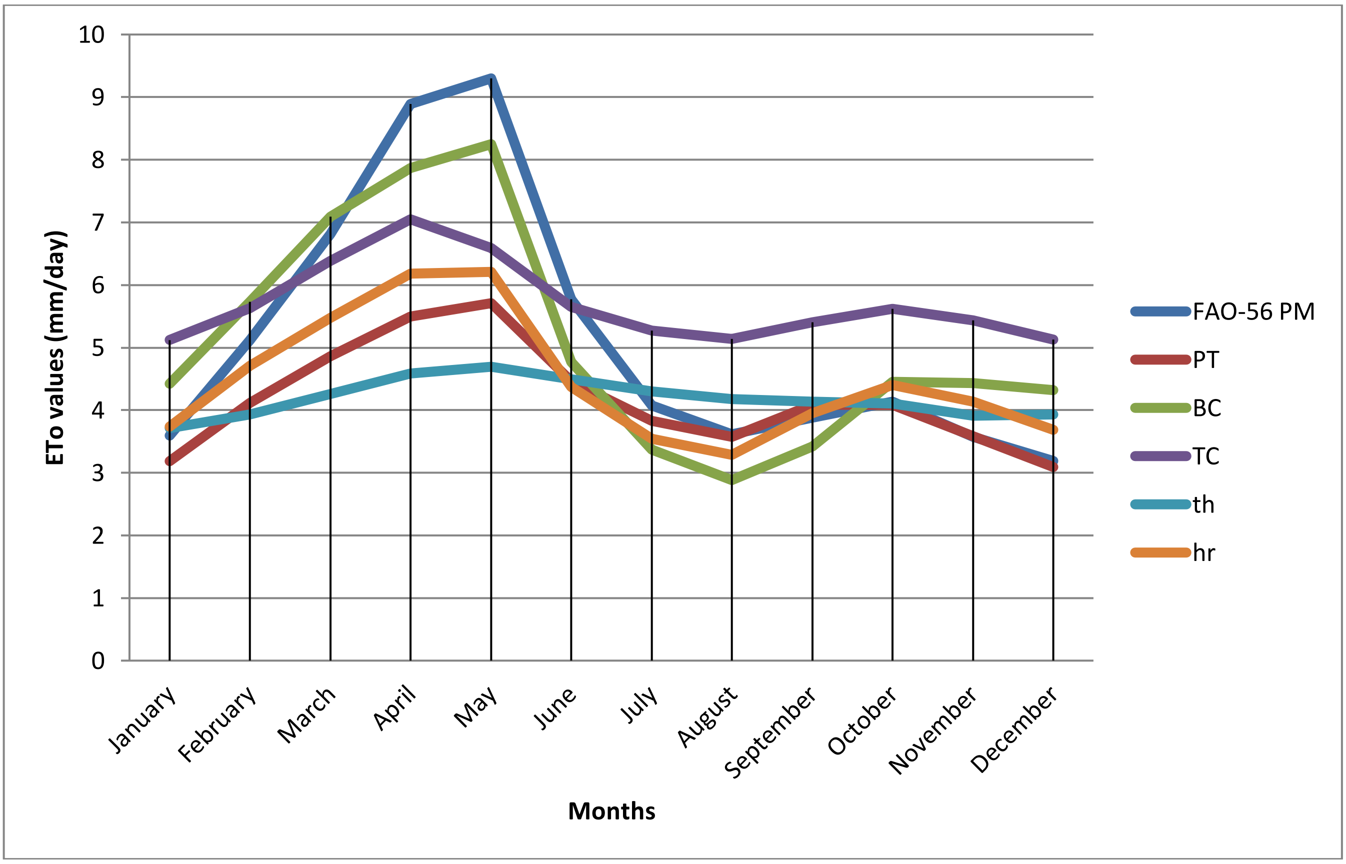

Figure 3- Graphical representation of monthly ET_o values by all method

Table 2 – Monthly ARE value against FAO-56 PM method

ARE\YEAR	January	February	March	April	May	June	July	August	September	October	November	December	Average
PT	0.11	0.19	0.28	0.38	0.38	0.22	0.06	0.01	0.05	0.01	0.004	0.030	0.147
BC	0.227	0.11	0.03	0.115	0.112	0.173	0.173	0.202	0.120282	0.075	0.242	0.354	0.163
TC	0.427	0.099	0.063	0.206	0.29	0.021	0.291	0.421	0.391	0.357	0.521	0.609	0.308
TH	0.031	0.231	0.375	0.484	0.495	0.221	0.053	0.154	0.066	0.008	0.094	0.233	0.204
HR	0.039	0.079	0.197	0.304	0.332	0.243	0.130	0.091	0.017	0.063	0.157	0.155	0.151

Table 3– Regression and Error analysis between monthly values of calculated ET_o

Methods	Regression equation	R^2	ARE	% deviation	SEE
PT	2.4473x – 5.0498	**0.92**	**0.147**	19.85	0.99
BC	1.1002x – 0.4275	0.85	0.163	**1.33**	**0.081**
TC	3.1882x – 13.012	0.91	0.308	21.09	0.53
TH	5.8005x – 19.121	0.66	0.204	21.35	0.97
HR	2.0287x – 3.9116	0.90	0.151	12.12	0.69

6.CONCLUSIONS

6.1 Comparison based on monthly basis and seasonal basis -

The comparative study concluded that on seasonal basis, for the summer season Blaney-Criddle was best among all method. For the rainy season and the winter season Priestley Taylor method provides better results and given as rank one.

On monthly basis, Priestley Taylor (radiation based method) provided good results of the comparison when compared to FAO-56 PM method. All other methods were given rank on the basis of the value of regression, ARE, SEE and the percentage deviation.

The best part of evapotranspiration is that, if the catchment characteristics of two areas are identical then calculated reference evapotranspiration values of one area can directly be applied to another area. Hence values which are calculated for Chaskaman command area can be applied to another area near to it which is having similar characteristics as that of Chaskaman command area. If the meteorological data is not available for our area then we can definitely use the alternative method for that area.

6.2 Crop water requirements -

FAO-56 PM method is unique standard method for calculating ET_o. All hydro meteorological data required is available for PM method and ETo values are also calculated in this study. Now simply select the crop coefficients (Kc), the water needs of crops are calculated.

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