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# PERFORMANCE OF DIFFERENT METHODS OF ESTIMATING POTENTIAL EVAPOTRANSPIRATION IN WESTERN VIDARBHA REGION

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***Abstract:*** *The water available for irrigation is shrinking due to diminishing water resources, increasing consumption and pollution. The estimation of Potential Evapotranspiration (PET) is an important aspect in water management due to scarcity of water and increase in population. PET got its enactments in the role of modeling and simulation of structural water bodies, hydrologic cycle and ecosystem balance. The comparative study of different methods of estimating PET viz., a highly data intensive FAO Penman-Monteith method as a standard in estimating the PET, and few other which are less data intensive and empirical methods, namely Blaney Criddle, Hargreaves and Turc methods have been carried out. Analyses of 30 years climatic data of Akola indicated that Blaney Criddle method has been proved to be better correlated method and is followed by Hargreaves with fewer data requirement as compared to FAO Penman Monteith method in Western Vidarbha Region of Akola.*

***Keywords:*** *Potential evapotranspiration, FAO-56 Penman-Monteith, Blaney Criddle, Akola.*

## Introduction

In India distribution of precipitation is very uneven and uncertain. For effective water management under water scarce situation, farmers have to adopt proper irrigation scheduling, for which it is essential to know environmental demand for surface water whose loss occurs primarily through evapotranspiration. The estimation of potential evapotranspiration is the most important step towards designing, planning and managing different irrigation networks, water distribution systems, water application, water balance and water management practices (Landeras et al., 2008 and Sentelhas et al., 2010). The estimation of potential evapotranspiration can be computed using several approaches, radiation based, water budget based, combination based and temperature based. The extensive data needed to get proficiency and to implement them with precision make the selection procedure critical for determining the optimistic method. The developed method may be inconsistent as they require different input and are based on varied assumption (Grismer et al., 2002). Many methods present in research work like pan evaporation method, Hargreaves-Samani, Turc, Thornwaite, Blanney-Criddle, Christiansen, FAO Penman-Monteith and Modified Penman-Monteith method have been proposed for estimating PET based on weather data and range from locally developed, empirical relationships to physically based energy and mass transfer models. To allow for greater understanding, sharing and inter-comparison of evapotranspiration information worldwide, under varying climatic and agronomic conditions, FAO Penman Monteith method is regarded as a standardized method of estimating evapotranspiration. But FAO Penman Monteith method demands much weather data that may be unavailable in various places hence there is need to come up with alternative methods. So, this study aims to evaluate the performance of different PET estimation method and compares with FAO Penman Monteith method to find out the appropriate and alternate PET estimation method with less data input in Akola region.

## Materials and Methods

### Study area and weather dataset

Daily weather parameters data set from the period of 1 January 1985 to 31 December 2014 (30 years) obtained for semi arid region of Akola has been obtained from AICRP on Agrometerology, Dr. PDKV, Akola and analysed on the basis of yearly, monthly and daily basis. Akola is located at latitude $20^0$ 42' North and longitude $77^0$ 07' East in western Vidarbha region of Maharashtra.

### Methods for estimating potential evapotranspiration

The Penman-Monteith method is FAO recommended standard and requires data as input at a greater extent. Daily meteorological data of maximum and minimum temperatures, wind speed, relative humidity, sunshine hours and solar radiation data is required by this standard method. In many station there is no source of collecting the all metrological data. In this case there is problem in estimating PET. Hargreaves, Blaney-Criddle, Turc and Christiansen which are primarily temperature based method and this methods do not require all parameters of weather for estimating PET. In this study, following methods are adopted for computation of PET,

1. Turc Method ( Turc, 1961)
2. Hargreaves Method (Hargreaves and Samani, 1985)
3. Blaney Criddle (FAO -24, Blaney Criddle,1977)
4. FAO Penman Montieth Method (Allen et al., 1998)

The benchmark method for comparisons was FAO modified Penman Monteith model because it is globally accepted and can be used under a variety of climatic regimes and reference conditions.

### Statistical Analysis

To ensure rigorous comparison of FAO Penman Montieth Method and other different methods to evaluate their performance, an extended analysis in terms of statistical indices namely, correlation coefficient (r), coefficient of determination ($R^2$), root mean square error (RMSE), normalized root mean square error (NRMSE), coefficient Willmott's index of agreement (d-index) has been carried out. The quantification of under and over estimation of FAO Penman Montieth Method and other different methods was done in terms of their ratio (PET method/ FAO PET method) and its value near to 1 was considered as good.

## Results and Discussion

Potential evapotranspiration by four different methods, namely Hargreaves, Turc, Blaney Criddle and FAO Penman Montieth Method which is primarily temperature based methods has been carried out. The result of these methods was correlated with FAO Penman Montieth method. The FAO Penman Montieth method which is FAO-56 recommended requires information regarding wind speed, maximum and minimum temperature, relative humidity, sunshine hours and solar radiation. The daily potential evapotranspiration values for each model were calculated and converted into monthly and yearly potential evapotranspiration. The trend in potential evapotranspiration on yearly and monthly is presented in Fig. 1 and 2.

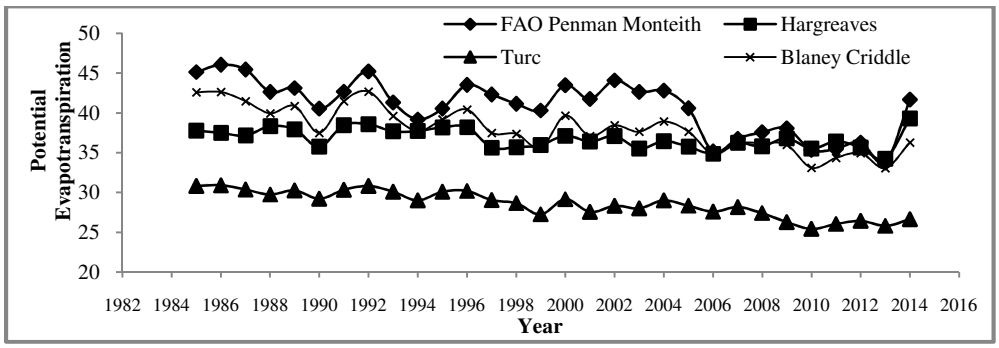


**Fig 1: Trend of yearly potential evapotranspiration simulated by FAO Penman Monteith and three empirical methods (from year 1985-2014).**

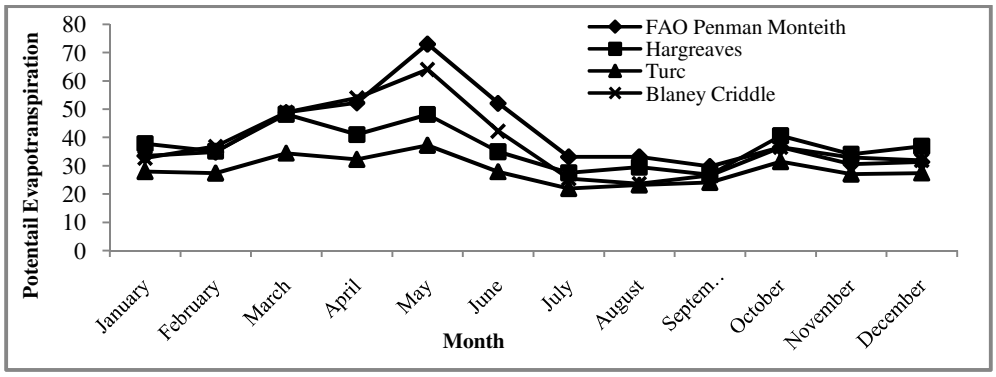


**Fig 2: Trend of monthly potential evapotranspiration simulated by FAO Penman Monteith and three empirical methods (Years 1985-2014)**

For all methods of estimating potential evapotranspiration, the highest yearly PET values were recorded in year 1986 (46.04 mm, 37.47 mm, 30.88mm and 42.61 mm) for FAO Penman Monteith, Hargreaves, Turc, Blaney Criddle, respectively. The lowest yearly PET were recorded as in year 2013 (33.74 mm, 34.22 mm, 25.80 mm, and 33.05 mm) for FAO Penman Monteith, Hargreaves, Turc, Blaney Criddle, respectively.

The highest monthly PET values were recorded in summer season (March to May) and the lowest monthly PET values were recorded in winter season (October to February). For all methods of estimating potential evapotranspiration, the highest monthly PET values were recorded in May (73.09 mm, 48.18 mm, 37.28 mm and 64.09 mm) for FAO Penman Monteith, Hargreaves, Turc, Blaney Criddle, respectively. The lowest monthly PET were recorded as in September (29.80 mm, 26.80 mm, 24.13 mm and 26.63 mm) for FAO Penman Monteith, Hargreaves, Turc, Blaney Criddle, respectively.

Comparisons were made between yearly, monthly and daily potential evapotranspiration values obtained from each empirical method with FAO modified Penman Monteith model.

The model with the highest index of agreement (d), correlation coefficient (r), coefficient of determination ($R^2$) also having low root mean square error (RMSE) and normalize root mean square error (NRMSE) is the best model. The Table 1, 2 and 3 shows the good correlation of FAO Penman Monteith model as compared to other method on daily, monthly and yearly basis.

All the statistical parameters revealed that PET estimated by Blaney Criddle and Hargreves method is very close to that of FAO Penman Monteith Model. Analyses of 30 years climatic data of Akola indicated that Blaney Criddle and Hargreves method compared reasonably well with FAO Penman Monteith model. Hargreaves-Samani model is the second best and Turc model is ranked third. Similar results are obtained by Rao and Rajput (1993). This revealed that Blaney Criddle method can successfully be used in the absence of adequate climatic data that is required for the use of FAO Penman Monteith model in the Akola region.

**Table 1: Summary of statistics of daily PET estimation method compare with FAO Penman Monteith during 1985-2014 at Akola**

| Equation/Methods | r | $R^2$ | RMSE | NRMSE | d-index | Ratio | Performance rating |
|---|---|---|---|---|---|---|---|
| Hargreaves | 0.71 | 0.50 | 10.62 | 0.26 | 0.76 | 0.9 | Very good |
| Turc | 0.77 | 0.59 | 16.08 | 0.39 | 0.54 | 0.69 | Good |
| Blaney Criddle | 0.90 | 0.82 | 6.53 | 0.16 | 0.91 | 0.93 | Excellent |

**Table 2: Summary of statistics of monthly PET estimation method compare with FAO Penman Monteith during 1985-2014 at Akola**

| Equation/Methods | r | $R^2$ | RMSE | NRMSE | d-index | Ratio | Performance rating |
|---|---|---|---|---|---|---|---|
| Hargreaves | 0.72 | 0.52 | 9.89 | 0.24 | 0.72 | 0.90 | Very good |
| Turc | 0.79 | 0.63 | 15.49 | 0.37 | 0.46 | 0.70 | Good |
| Blaney Criddle | 0.92 | 0.86 | 5.40 | 0.13 | 0.94 | 0.93 | Excellent |

**Table 3: Summary of statistics of yearly PET estimation method compare with FAO Penman Monteith during 1985-2014 at Akola**

| Equation/Methods | r | $R^2$ | RMSE | NRMSE | d-index | Ratio | Performance rating |
|---|---|---|---|---|---|---|---|
| Hargreaves | 0.62 | 0.39 | 4.87 | 0.11 | 0.38 | 0.90 | Very good |
| Turc | 0.80 | 0.64 | 12.46 | 0.31 | 0.19 | 0.73 | Good |
| Blaney Criddle | 0.89 | 0.80 | 3.16 | 0.07 | 0.77 | 0.93 | Excellent |

## Conclusions

Determination of correct potential evapotranspiration is an important aspect in water management. In the present study a highly data intensive, well known FAO Penman Monteith method has been used to compute potential evapotranspiration for Akola region. Three different methods which are less data intensive and empirical are also used to compare with FAO-56 Penman Monteith method. Analyses of 30 years climatic data of Akola indicated that Blaney Criddle and Hargreves method compared reasonably well estimating the potential evapotranspiration as compared to FAO Penman Monteith method.

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