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# Estimation of PET by empirical models for north eastern hill region of Meghalaya

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## ABSTRACT

Mesh covered pan evaporation was correlated with the estimated values of potential evapotranspiration (PET) and/or consumptive use using Thornthwaite (1948), Blaney-Criddle (1950) and Papadakis (1965) models for the period of 1985-2000 at Umiam, Meghalaya. The results revealed that the Papadakis method was most suitable with least biasness and highest accuracy of prediction. The PET values from Papadakis method were more evenly distributed along the 1:1 line. From the analysis it was also observed that correlation coefficient (r) was not an appropriate measure to determine the accuracy of estimation of PET by different methods for the location under study.

*Key words*: Correlation, Error analysis, Models, Pan Evaporation, PET

Rainfed agriculture is practiced in North East hill region of the country. By virtue of its location, this region gets plenty of rainfall during the monsoon season. Steps have been initiated by the state government to conserve the excess water in rain water harvesting ponds so as to recycle it during the lean period. It is well established that the evapotranspiration plays a major role for determining crop water requirement and several methods are available to determine. The lysimetric method, though very much accurate, can not be used everywhere because of high cost involved in installation and maintenance. On the other hand, actual pan evaporation data is available for very few locations only. Hence, in absence of the actual data, the empirical models developed by different worker have great role in estimating potential evapotranspiration (PET) of an area. The objective of this study was to compare three empirical methods for estimation of PET with the actual mesh covered pan evaporation (PE) for Umiam, Meghalaya.

## MATERIALS AND METHODS

Sixteen years (1985-2000) of weather data for Umiam (25°41′ N latitude and 91°55′ E longitude and altitude of 1010 m above msl), Meghalaya was used to compute the PET on monthly and seasonal basis by Thornthwaite method (Thornthwaite, 1948), Blaney-Criddle method (Blaney and Criddle, 1950) and Papadakis method (Papadakis, 1965).

The relationship of the estimated PET, by three different empirical methods, was compared with the mesh covered pan evaporation data. Mean error (ME), absolute mean relative error (AMRE) and root mean square prediction difference (RMSPD) were used to evaluate the general applicability of the models. The expressions for these statistical relationships have been given below:

$$ME = \frac{1}{n}\sum_{i=1}^{n}\left(y_i - \bar{y}_i\right),$$

$$AMRE = \left|\frac{1}{n}\sum_{i=1}^{n}\frac{\left(y_i - \bar{y}_i\right)}{y_i}\right|,$$

$$RMSPD = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(y_i - \bar{y}_i\right)^2}$$

where,

$y_i$ : Observed value of pan evaporation (mm)

$\bar{y}_i$ : Estimated value at i[th] observation (mm)

n : Total number of observation

Correlation study was done between PET (y) and pan evaporation data (x) for different methods.

## RESULTS AND DISCUSSION

Monthly and seasonal values of pan evaporation (PE) with estimated potential evapotranspiration (PET) by different methods at Umiam has been presented in Table 1. Statistical analysis revealed that actual monthly PE was the lowest in the month of December and the highest in April. Similarly during summer season (March-May) the PE was highest. It was also observed that the estimated values of PET obtained from Papadakis method at this location were closest to the actual PE values for most of the months. Blaney-Criddle and Thornthwaite methods overestimated PET for monsoon (June-September) season and under estimated for rest of the months of the year. Estimated PET by Papadakis method were almost identical with PE values for monsoon season, slightly higher for post-monsoon (October-November) and lower for winter (December-February) periods. This simple analysis shows that values from all the three methods are closer to pan evaporation in the month of October and (a) in winter and monsoon seasons. Papadakis methodgive a closer seasonal estimates (b) Blaney-Criddle estimate are better used in summer and post monsoon seasons at this station.

The error analysis has been presented in Table 2 (a, b, c). The ME values were least in case of Papadakis method (ME ranged from -8.14 in post-monsoon to 30.02 in summer seasons) followed by Thornthwaite (ME ranged from -33.85 in monsoon to 43.13 in winter seasons) and Blaney-Criddle (ME ranged from -47.29 in monsoon to 26.98 in summer seasons) methods. The Blaney-Criddle and Thornthwaite methods generally overestimated evapotranspiration to a great extent.

**Table 1:** Monthly and seasonal values (mean ± s.d.) pan evaporation (PE) and potential evapotranspiration (PET) as estimated by different methods at Umiam

| Month/ Season | PE ± s.d. | PET (mm) | | |
|---|---|---|---|---|
| | | Papadakis | Blaney-Criddle | Thornthwaite |
| January | 71.5 ± 6.4 | 71.1 ± 8.0 | 52.1 ± 1.7 | 25.2 ± 4.1 |
| February | 89.4 ± 13.8 | 80.5 ± 11.7 | 58.5 ± 2.9 | 34.8 ± 7.7 |
| March | 123.3 ± 20.3 | 100.8 ± 13.2 | 84.2 ± 2.6 | 66.1 ± 8.4 |
| April | 139.1 ± 32.8 | 103.2 ± 12.7 | 101.0 ± 3.9 | 92.8 ± 13.0 |
| May | 129.9 ± 24.3 | 93.2 ± 9.2 | 120.2 ± 2.9 | 108.5 ± 9.7 |
| June | 87.5 ± 9.8 | 85.4 ± 9.4 | 131.6 ± 2.6 | 120.9 ± 8.3 |
| July | 97.1 ± 14.9 | 78.0 ± 8.4 | 144.6 ± 2.0 | 127.2 ± 6.2 |
| August | 76.1 ± 10.8 | 85.6 ± 11.1 | 138.4 ± 1.5 | 120.7 ± 4.7 |
| September | 73.0 ± 10.1 | 84.7 ± 12.7 | 108.3 ± 1.7 | 100.3 ± 5.2 |
| October | 86.4 ± 7.6 | 86.9 ± 8.6 | 86.0 ± 1.7 | 80.9 ± 5.5 |
| November | 67.0 ± 5.5 | 82.8 ± 14.6 | 65.8 ± 2.5 | 51.1 ± 7.6 |
| December | 60.7 ± 8.6 | 77.2 ± 9.1 | 54.1 ± 1.7 | 32.2 ± 4.3 |
| Winter | 73.9 ± 15.5 | 76.3 ± 10.3 | 54.9 ± 3.4 | 30.7 ± 6.9 |
| Summer | 128.8 ± 26.8 | 98.8 ± 12.5 | 101.8 ± 15.2 | 89.1 ± 20.5 |
| Monsoon | 83.4 ± 14.9 | 83.4 ± 10.8 | 130.7 ± 14.0 | 117.3 ± 11.9 |
| Post-Monsoon | 76.7 ± 11.8 | 84.8 ± 12.0 | 75.9 ± 10.5 | 66.0 ± 16.4 |

In addition to ME, application of AMRE and RMSPD measures confirmed the performance of different methods. The biasness of the methods can be obtained from AMRE values. The overall biasness was found lowest in case of Papadakis method (AMRE ranged from 0.03 in monsoon to 0.21 in summer seasons) followed by Thornthwaite (AMRE ranged from 0.14 in post-monsoon to 0.57 in winter seasons) and Blaney-Criddle (AMRE ranged from 0.004 in post-monsoon to 0.60 in monsoon seasons) methods. The accuracy of estimation is given by RMSPD analysis. Lower the value of RMSPD better is the accuracy of prediction. Among the three empirical methods, Papadakis method outperformed Thornthwaite and Blaney-Criddle methods.

But from the correlation studies, between PET (y) and PE (x) for different seasons, it has been observed that in case of Papadakis method, correlation coefficients (r) were not significant except for summer season (r = 0.42*), where as from the error analysis this method emerged out as best among all the three methods. The general closeness of the PET, obtained from Papadakis method, with PE values also confirms it. The Thornthwaite method, which otherwise not found best, showed

**Table 2:** Statistical comparison of different empirical methods of PET estimation with the pan evaporation data

(A) Papadakis Method

| Season | ME | AMRE | RMSPD | Linear relationship | r |
|---|---|---|---|---|---|
| Winter | -2.40 | 0.07 | 16.76 | y = 0.14x + 66.0 | 0.21 |
| Summer | 30.02 | 0.21 | 38.47 | y = 0.20x + 73.30 | 0.42* |
| Monsoon | 0.014 | 0.03 | 18.48 | y = -0.02x + 85.42 | 0.03 |
| Post Monsoon | -8.14 | 0.13 | 16.87 | y = 0.21x + 68.99 | 0.20 |

(B) Blaney-Criddle Method

| Season | ME | AMRE | RMSPD | Linear relationship | r |
|---|---|---|---|---|---|
| Winter | 18.96 | 0.23 | 23.37 | y = 0.13x + 45.28 | 0.59** |
| Summer | 26.98 | 0.18 | 39.48 | y = 0.07x + 92.75 | 0.12 |
| Monsoon | -47.29 | 0.60 | 49.53 | y = 0.44x + 93.72 | 0.47** |
| Post Monsoon | 0.83 | 0.004 | 7.08 | y = 0.71x + 21.31 | 0.80** |

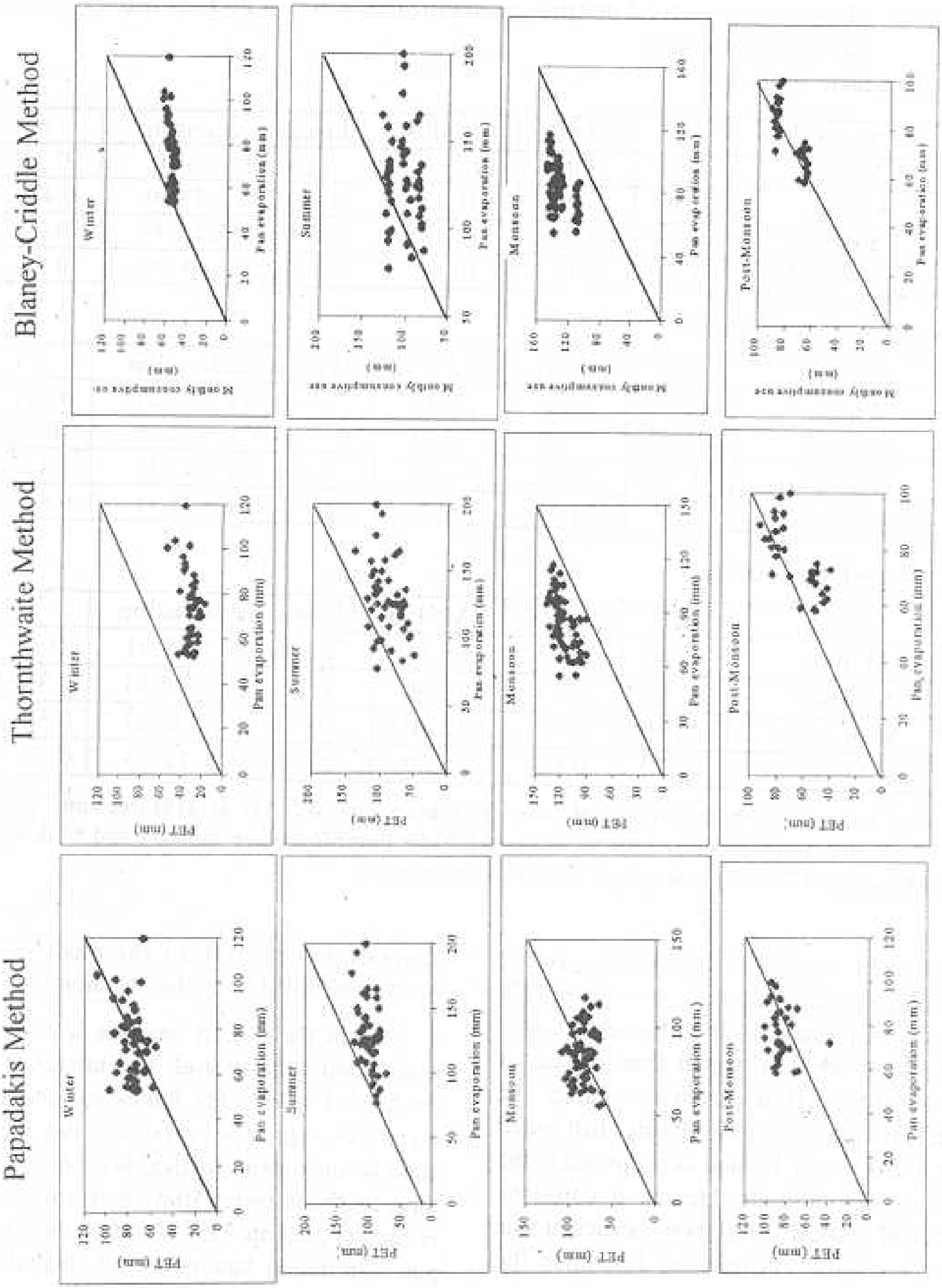
(C) Thornthwaite Method

| Season | ME | AMRE | RMSPD | Linear relationship | r |
|---|---|---|---|---|---|
| Winter | 43.13 | 0.57 | 45.54 | y = 0.15x + 19.91 | 0.33* |
| Summer | 39.67 | 0.29 | 48.04 | y = 0.27x + 54.34 | 0.35** |
| Monsoon | -33.85 | 0.44 | 36.36 | y = 0.41x + 82.73 | 0.52** |
| Post Monsoon | 10.70 | 0.14 | 15.29 | y = 1.02x – 12.63 | 0.73** |

r = Coefficient of correlation, n = Total numbers of observation d.f. = Degrees of freedom = (n-2), (46 for Winter and Summer, 62 for Monsoon and 30 for Post Monsoon seasons) * and ** denotes significance at 5 % and 1% levels of probability, respectively

maximum significant correlations. In the Fig.1 pan evaporation vs. estimated PET has been presented for different methods. The plots also suggested that in case of Papadakis method except in summer the PET values were more evenly distributed on both sides of 1:1 line as compared to the other two methods. Hence, it could be inferred that the correlation coefficient was not a suitable measure to determine the general applicability of the models for estimation of PET for this location.

From the overall analysis it may be concluded that though the correlation coefficient values for Papadakis method were not highly significant, the error analysis ranked this method best among the three methods under study and hence can be used to estimate PET in absence of actual pan evaporation data for hills of Meghalaya


Blaney-Criddle Method
Thornthwaite Method
Papadakis Method
Winter
Summer
Monsoon
Post-Monsoon
Pan evaporation (mm)
Monthly consumptive use (mm)
PET (mm)

region.

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