# Performance Evaluation of Mass Transfer-Based Method using Global Performance Index in Semi-Arid Region Saudi Arabia

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## Abstract

The standard method for the estimation of reference evapotranspiration (ETo) is FAO-Penman-Monteith (FAO56-PM). However, it requires various climatic parameters which are often hard to achieve due to various reason. In order to bridge this gap an alternative equation has to be find out. The main aim of this research work was to assess the performance of the various mass transfer-based method with respect to standard FAO56-PM. Daily meteorological data from 1980 to 2018 has been used to compute reference evapotranspiration. Daily ETo values were computed. Among the computed values 70% of them were used to calibrate the mass transfer equations under study and remaining 30 % data were used to validate the calibrated equation against the standard method. The calibrated models were analysed and compared using statistical tools and ranked using Global Performance Indicator where a higher value represented a model's better performance. The models were then arranged using GPI and it was found that Albrecht model resulted in best estimation capability. The results of this study could be used by the water management system, crop cultivators, crop advisors, researchers and students from universities and research centres. Moreover, it is beneficial for the decision maker in the vast field of agriculture, hydrology and environment.

**Keywords**: Reference Evapotranspiration; Mass Transfer method; Calibration; Validation; Global Performance Index

## 1. Introduction

statistical measures finally based on evaluation criteria the ranking were done in order to get most promising model based on global performance index as shown by equation 2 which can be used alternative to FAO56-PM model as given by equation 1.

$$ETo = \frac{0.408 \times \Delta \times (Rn - G) + \gamma \times \left(\frac{900}{T+273}\right) \times u_2 \times (e_s - e_a)}{\Delta + \gamma \times (1 + 0.34u_2)}$$

(1)

The most accurate methods for this estimation is to use lysimeter measurements (Xu *et al.*, 2013). However, lysimeter measurements are relatively difficult, expensive, and time consuming. Therefore, the FAO (Food and Agriculture Organization of the United Nations) recommends an alternative method, i.e., the Penman-Monteith FAO-56 (PMF56), which was developed on the basis of lysimeter measurements in various regions around the world (Allen *et al.*, 1998). However, this model has its own shortcoming due to requiring lots of meteorological parameters which are not easily-measured factors. Therefore, , using a lesser number of input variables including mass transfer are frequently used instead (Sentelhas, Gillespie and Santos, 2010).In this research work effort has been made to evaluate , calibrate and validate various mass transfer reference evapotranspiration equation.

## 2. Methodology

In this research work, weather parameters were collected from Abha meteorological weather station for the period between 1980–2018. Reference Evapotranspiration were estimated by nine reference evapotranspiration model based on available climatic data. The values estimated from different equations were compared with the reference value obtained from FAO56-PM for the period between 1978-2017. Further all nine equation were calibrated for then validation of calibrated equation with respect to FAO56-PM model. The performance of equations was evaluated by utilizing several

$$GPI_i = \sum_{j=1}^{10} \alpha_j (\tilde{y}_j - \tilde{y}_{ij})$$

(2)

where, $\alpha_j$ have a value of +1 for statistical errors having a recommended value of 0 and a value of -1 for statistical errors that have a recommended high value of 1 (e.g. R). $\tilde{y}_j$ and $\tilde{y}_{ij}$ are the median and scaled values, respectively.

## 3. Result and Discussions

The daily reference evapotranspiration estimates produced using nine simplified mass transfer equation and proposed equation were compared against the FAO56-PM evapotranspiration data. When solar radiation or sunshine duration data were lacking, the best performance at the daily time scale was obtained by the mass transfer-based equation. While evaluating the performance of mass transfer equation against Standard FAO56-PM, the best estimates were obtained by proposed equation with high determination coefficient $(R^2=0.96)$, $(MAE=0.2mm/day; RMSE=0.228mm/day; RE=0.1; U_{95}=1.05\%; RMSRE=0.117; RRMSE=0.09; MBE=0.2mm/day; erMax=0.23; t-Statistic=18.47 mm/day)$. The Figure 1 shows the out for evaluated Calibrated and Validated equation
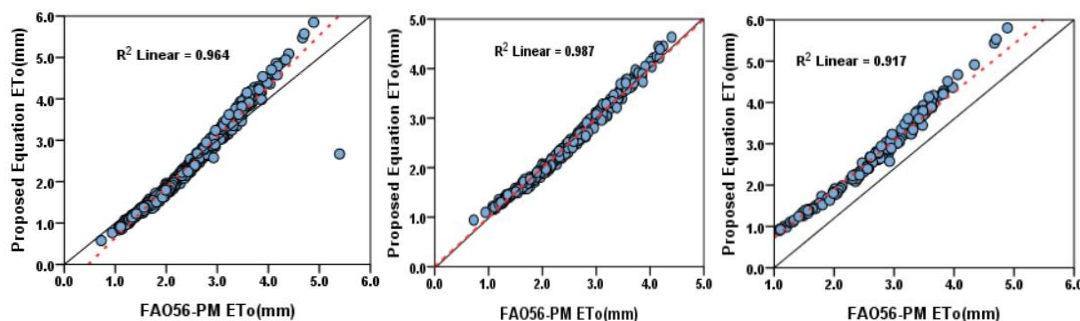


**Figure 1**: Regression result for evaluated, Calibrated and Validation for Best Model

## 4. Conclusion

The current study was performed with an aim to evaluate the nine-mass transfer reference evapotranspiration models and one proposed equation with respect to standard FAO56 PM model in the semi-arid region of Kingdom of Saudi Arabia. According to the results, calibration significantly enhance the performance of equation. In the models calibrated, the proposed model estimates for reference crop evapotranspiration in Abha region gives output better than the other models. Moreover, the validation of calibration equation shows that proposed equation gives better result.

## References

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