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REVIEW ON A COMPARISON OF EVAPOTRANSPIRATION METHODS

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Abstract - *Evapotranspiration (ET) plays an important role in water balance studies of an irrigation command area. Accurate estimation of evapotranspiration is necessary step in water resource management. Evapotranspiration varies spatially and temporally. During the last fifty years, a large number of empirical methods have been developed and used to estimate ETo (reference evapotranspiration). FAO-56 Penman-Monteith (FAO-56 PM) method for calculating reference evapotranspiration (ETo), as this method is applicable to all types of season and different climates and gives more accurate result. FAO-56 PM method requires very large amount of meteorological data, which may not available at all climate station. So due to unavailability of data, there is need to find out the next best suitable method after FAO-56 PM method, which will give ETo results nearer to FAO-56 PM method.*

Key words- *Evapotranspiration, statistical, evaluation, FAO-56 Penmen Monteith Equation, water balance*

I. INTRODUCTION

Evaporation is the process whereby liquid water is converted to water vapour (vaporization) and removed from the evaporating surface (vapour removal). Evaporation accounts for the movement of water from a variety of surfaces, such as lakes, rivers, pavements, soils and wet vegetation. Transpiration accounts for the movement of water within a plant and the subsequent loss of water as vapour through stomata in its leaves.

Evapotranspiration (ET) is the combination of evaporation and transpiration from the Earth's land and ocean surface to the atmosphere. Evapotranspiration is an important part of the water cycle.
Reference evapotranspiration (ET0), is a representation of the environmental demand for evapotranspiration and represents the evapotranspiration rate of a short green crop (grass), completely shading the ground, of uniform height and with adequate water status in the soil profile.

II. LITERATURE REVIEW

Following are some research papers that studied to assesses valuating ETo for the study area. There view of all papers will help in estimating the next best suitable method after FAO-56 PM method for calculating ETo. This study will helpful for finding ETo while some meteorological data are missing.

Sujata Shreedhar, Dr. Venkatesh B, Dr. Purandara B. K. [1]
Evapotranspiration is an important component in water-balance and irrigation scheduling models while the FAO-56 Penman-Monteith method has become the defacto standard for estimating reference evapotranspiration (ETo), it is a complex method requiring several weather parameters. Required weather data are often times unavailable and alternative methods must be used.

Biligihole watershed in Western Ghats of India is considered for this study. In this study, four alternative ETo methods, the Hargreaves method, Turc method, mikkink method and Priestly-Taylor Method were evaluated for use in Biligihole watershed with available data. Methods are ranked separately on the basis of SEE, MXE, MAE, RMSD, R^2 values. Also methods are ranked overall by calculating average of rank number from all the statistical parameters.
From the analysis itis found that Hargreaves method perform better and therefore it is recommended as the empirical method for estimating the ETo values for the Biligihole watershed.

Alivia Chowdhury, Debaditya Gupta, Dhananjay Paswan Das, Anirban Bhowmick [2]
The accurate estimation of reference evapotranspiration (ETo) plays a pivotal role in water resources planning and management studies.

In this study, three temperature based methods namely, Blaney-Criddle method, Thornthwaite method and Hargreaves – Samani model and three radiation based methods namely, Turc method, Priestly-Taylor model, and FAO-24 Radiation Model are considered for Mohanpur area, Nadia district, West Bengal.

Computed values of ETo by the above methods are compared with FAO Penman -Monteith (FAO - 56 PM) method, which was considered as the standard method of ETo estimation, to check the capabilities of different models to predict

ETo for the study area. The present analysis was carried out using 10-years daily weather data of Mohanpur weather station. The results of the study showed that, the ETo values were in the range of 3.5 mm/day to 5.0 mm/day at Mohanpur, Nadia district, West Bengal, India. A rank was given to different methods based on the comparative analysis of different ETo estimation methods with FAO-56 PM method and it could be inferred that Turc method as the closest method and Thornthwaite method as the least-matched method to FAO 56 Penman-Monteith for the study area.

Othoman ALKAEED, Clariza FLORES, Kenji JINNO and Atsushi TSUTSUMI [3]
In this study, Six evapotranspiration (ETo) methods are compared, based on their daily performances under the given climatic condition in the western region of Fukuoka City. Thornthwaite, Hargreaves, and Hamon methods are compared with the Penman-Monteith equation. The FAO56-PM method has also been used as an index for two equations: the solar radiation (R_s) based and net radiation (R_n) based equations, which are the simplified versions of FAO56-PM.

Performance analysis for the calculated values using meteorological data for 7 years (Jan 1996 – Dec 2002) was made. The standard error of estimates (SEE) was calculated on monthly basis. The estimated values by the Thornthwaite, Hargreaves, Hamon, and the R_s-based and R_n-based radiation methods were all correlated with FAO56-PM having correlation (r^2) values calculated by Pearson's correlation. The Thornthwaite method, which uses only temperature data as input, has been found to have highly correlated with the FAO56-PM method. Thus, when considering the availability and reliability of the input data, the use of all these methods are suggested as practical methods for estimating ETo if the standard FAO56-PM equation is not applicable due to the complexity of its input parameters.

Devendra M. Amatya, Ph.D., P.E.; and Charles A. Harrison [4]
Studies examining potential evapotranspiration (PET) for a mature forest reference compared with standard grass are limited in the current literature. Data from three long-term weather stations located within 10 km of each other in the USDA Forest Service Santee Experimental Forest (SEF) in coastal South Carolina were used to (1) evaluate monthly and annual PET estimates from five different methods with varying complexities [Penman-Monteith (P-M), Turc, Thornthwaite (Thorn), Priestley-Taylor (P-T), and Hargreaves-Samani (H-S)] at two grass reference sites; and (2) compare results for the grass sites with PET estimated using the P-M method for a forest reference site using measured daily climatic data for the 2011–2014 period. At the WS80 forest site, the highest annual PET (1,351 mm) was observed in 2011 with the lowest rainfall (934 mm), and the lowest PET (1,017 mm) was observed in 2013 with the highest rainfall (1,433 mm), which is consistent with the two grass sites. The temperature-based H-S method yielded estimated monthly and annual PETs that were in better agreement than those of another temperature based Thorn method at both grass sites when compared against the P-M PET for the forest site.

When compared with the P-M PET for the forest site, the P-T method was in the closest agreement, with the highest R^2 of 0.96 and the least bias of 9.7% in mean monthly estimates, followed by the temperature based H-S with an R^2 of 0.95 and a bias of 12.6% at the SHQ grass site.

It is concluded that the simpler P-T and H-S methods appear to be adequate to estimate forest P-M PET and that their estimates are within the error bounds of the data-intensive P-M PET method for coastal forests.

Pedro Gavilán; Javier Estévez; and Joaquín Berengena [5]
ASCE and FAO-56 standardized reference evapotranspiration (ETo) equations were compared using data from 31 meteorological stations in Andalusia, Southern Spain. Comparisons were made between daily ETo obtained by summing hourly standardized ASCE–Penman–Monteith estimations and calculated from the addition of hourly FAO56–Penman–Monteith estimations, daily ETo estimated on a daily basis, and calculated by the Hargreaves equation. On an hourly basis, the FAO-56 version estimated lower than the ASCE version as 6% in some locations, with a difference of 4% on the average, mainly due to the higher surface resistance (70 s m−1) used in the FAO-56 version during daytime periods, as opposed to the 50 s m−1 r_s value used by the ASCE version. Differences between both estimates were higher when evaporative demand increases. The level of agreement improved when the two computational time steps were compared, because differences were lower (2% on the average) and did not depend on the wind speed or ETo values. The Hargreaves equation showed a higher spatial variability. At coastal areas, the equation generally under predicted ASCE Penman–Monteith ETo and provided good estimations for inland locations. Accuracy of the equation was affected by annual averages of evaporative demand and wind speed.

Ozgur Kisi [6]
Estimation of reference evapotranspiration (ETo) is very important for water resources management, and determination of the water budget especially under arid conditions. The applicability of simple Penman Equation's forms which are recently developed by Valiantzas (2013) is investigated in this study. The new empirical equations were applied to daily climatic data from four stations, Adana, Antalya, Isparta and Mersin, located in Mediterranean Region of Turkey. The results are compared with the reference evapotranspirations (ETo) obtained by FAO 56 Penman-Monteith (PM) and

following empirical equations; Copais, Turc, Hargreaves-Samani, Hargreaves, Ritchie and Irmak. Root mean square errors, mean absolute errors and determination coefficient statistics are used for comparison of the empirical models.

The results indicate that the Valiantzas' equation with full weather data performs better than the other empirical methods in Adana, Antalya and Isparta stations. In Mersin station, however, Copais equation performed the best out of nine methods. The worst estimates are generally obtained from Turc method.

III. CONCLUSION

This study will be beneficial for all the people who are coming under this study area. Though the performance and accuracy of FAO-56 Penman-Monteith method can never be debated in theoretical or practical applications yet the comparative evaluation performed in this study can be used as guidelines for selection of alternative or less data dependent methods in case of non-availability of data.

As the ETo values are vary temporally as well as spatially, if one watershed characteristics matches with the other watershed (with calculated ETo) then we can apply same equation for that watershed where all data are not available. This study will helpful for finding crop water requirement and calculating the design discharge in the main canal and hence water balance system can be developed.

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