Estimation of Reference Evapotranspiration Over Kancheepuram District, India

D. Soundarrajan[1], M.M.Vijayalakshmi[2], P.Partheeban[3], S.Poongothai[4]

[1]Research Scholar, Department of Civil Engineering, Sathyabama University, Chennai
[2]Department of Civil Engineering, Sathyabama University, Chennai
[3]Dean, St.Peter's University, Avadi, Chennai
[4]Department of Civil Engineering, Annamalai University, Chidambaram.
Email ID: [1]dsr_j@yahoo.co.in, [2]vnat12345@gmail.com

Abstract–

Water is the basic need for life existence. In the hydrologic cycle the evapotranspiration plays a vital and complex role. Estimation of Evapotranspiration (ETo) in a accurate manner is essential for all the practices of water management in a efficient way especially for agricultural based developing country India. This paper investigates the estimation of evapotranspiration models in agricultural industry mainly for paddy production. India is the second largest producer of rice in the world, it requires high temperature above 25^0c with annual rainfall above 100 cm, mainly grown in north and north-eastern India, coastal and deltaic reason. The performance of the model was evaluated by using the statistical parameters such as Correlation coefficient (R^2) and root mean square error (RMSE), the water losses due to evapotranspiration in surface water can be determined.

Key Words: Evapotranspiration, penman-monteith, FAO56, Pan Evaporation, Kancheepuram district

I. INTRODUCTION

Water is literally the source of life on earth. Water related problem is clearly the single largest problem facing India today. With the explosion of population, requirement for water is on the increase. The available supplies of water will prove to be inadequate [2]. To meet the ever increasing population in India, the agricultural production has to be increased manifold. Therefore the largest use of water in India is for irrigating lands. Water is also a crucial element in the socio economic development of the country. This has resulted in the need of proper water management techniques by water policy-making agencies and irrigation managers on the agricultural lands. One of the potential ways to improve water management is to asses reliably the evaporative losses. Water is provided to the crops naturally through precipitation and Humidity in the environment. Once these requirements proves to be inadequate for crop cultivation, farmers must depends on irrigation. Water availability is so critical for other sectors of the economy, including industry, the energy sector, and public use[1,8].

The loss of water by evapotranspiration is an important factor in water resources and hydrological studies. Most of the hydrologic, water management and crop growth models require an accurate estimate of potential evapotranspiration (PET) for reliable application. Several empirical methods have been developed over the last 50 years to estimate evapotranspiration from different climatic variables [5]. Relationships were often subject to rigorous local calibrations and proved to have limited global validity.

II. STUDY AREA

Kancheepuram, the temple town is the District headquarters. The District Kancheepuram is situated on the northern East Coast of Tamil Nadu and is adjacent by Bay of Bengal and Chennai city and is bounded in the west by Vellore and Thiruvannamalai district, in the north by Thiruvallur district and Chennai district, in the south by Villuppuram district in the east by Bay of Bengal. It lies between 11° 00' to 12° 00' North latitudes and 77° 28' to 78° 50' East longitudes. It has a total geographical area of 4393.37 Sq.Kms and coastline of 57 Kilometers. Agriculture is the main occupation of the people, 47% of the total population engaged in the District. The major crop cultivated in this District is Paddy with other crops like Millets, Cereals, Pulses, Sugarcane and Groundnuts,. The north east monsoon rainfall is almost uniform throughout the district. The coastal Taluks gets more rain than the interior regions. The existing maximum temperature is 21°C to 43°C and the minimum temperature ranges from 21°C to 25°C.

KANCHEEPURAM DISTRICT

Fig.1. Study area - Kancheepuram district

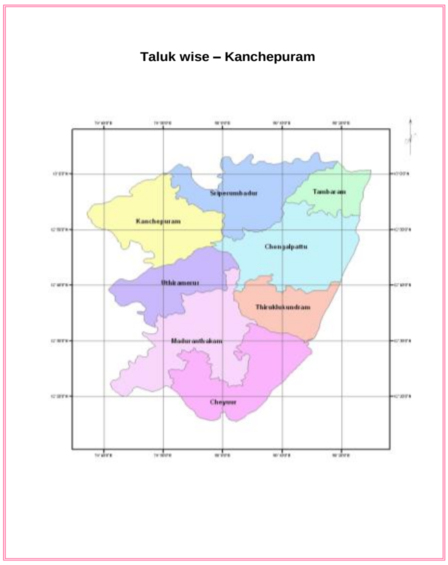

Fig.2. Study area - Kancheepuram District Taluk Wise

III. MATERIALS AND METHODS

In this study four models were used to estimate ET_o using Meteorological data. Most of the models require measured daily maximum and minimum temperature as input data. The daily mean temperature is the average of daily maximum and minimum temperature. Some models require humidity or solar radiation in addition to measured temperature. FAO Penman-Monteith model requires Daily mean temperature; wind speed, humidity and radiation. If measured solar radiation was not available, solar short wave radiation can be calculated using Angstrom equation. This equation requires measured and recorded daily bright sunshine hours.

A. Methods

The data were arranged in the specified format, year wise and files were created for each year and month for the location. Calculate ET_o on daily basis for a location and model. From the computed daily ET_o, monthly ET_o, mean daily ET_o and mean monthly ET_o for a period can be calculated. Daily ET_o and monthly ET_o refers to daily total value of ET_o and monthly total value of ET_o for each daily and month of a year respectively. Mean daily value of ET_o averaged over each month of a year ET_o (period) refers to daily value of ET_o averaged over each corresponding week of a multi-year period. Calculate and evaluate analysis of daily ET_o and monthly ET_o for a period can also be estimated. Daily ET_o (period) refers to daily total value of ET_o for each corresponding daily of a multiyear period and monthly ET_o (period) refers to monthly total ET_o for each corresponding month of a multi-year period.

B. Selection of models for modification

A plot was made to represent the percent error in estimated mean weekly ET_o by anyone model with reference to PM model. A line graph was established. Line graphs of all the models were incorporated in one sheet for each location to make it easy for comparison. Based on percent error, 'R^2', 'a' and 'b' values obtained for a stations, Penman-moteith ,BlaneyCriddle ,Priestley-Taylor ,Penman, models were selected and modified by recalibrating their constants involved in the original and constant equation. These modified equations were applied over of Kanchipuram (karunguli) expecting that the modified equation of any one model to estimate the value of ET_o closer to the corresponding value of ET_o of Penman-Monteith model[11]

The Blaney-Criddle This method used measured data on temperature only. The method is not very accurate It should be noted. That this; it provides a rough estimate or "order of a magnitude" only. **Jensen et al. (1990)**[2]`

The Priestley-Taylor: The ET process was controlled by available energy and the ability of evaporated water from the surface to be transferred. The transfer process was a function of the wind speed and the amount of water vapor in the air closest to the surface. **Priestley and Taylor (1972**) demonstrated that for a well-water surface that extends over a large surface area, the ET process was well described by air temperature , net radiation, and pressure. However, **Jensen et al. (1990)** found the radiation methods considerably underestimated ET for rates greater than 4 mm/day. [8,11]

The Penman-Monteith equation and associated equations for calculating aerodynamic and bulk surface resistance were combined and reduced to a single equation having two constants which have. The constants vary as a function of the reference surface and time step (hourly or daily). This summary of the ASCE PM-2000 approach only uses the grass crop reference that was relevant to the irrigation environment.[8,11]

Penman Method The classical Penman equation (Penman, 1948) was a combination equation that considers both the energy and aerodynamic aspects of the ET process. However, instead of the resistances (ra and rs) found in Penman-Monteith method, the Penman equation has an empirical wind function (the original coefficients were used in this study) [11].

IV. RESULTS & DISCUSSION

The meteorological Daily parameters like maximum air temperature, minimum air temperature, wind speed, sunshine hours and duration , relative humidity for Kancheepuram District India. were considered for the present study. The program will calculate daily reference evapotranspiration (ET_0) for the karunguzi station Kancheepuram District and monthly reference evapotranspiration, depends on user requirement.

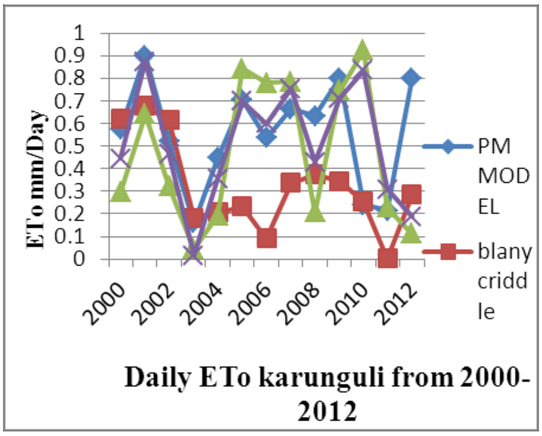

Fig.3. Performance of ETo models,PM -model, Billany-Criddle,Priestly-Tailors & Penman method for the year 2000 to 2012

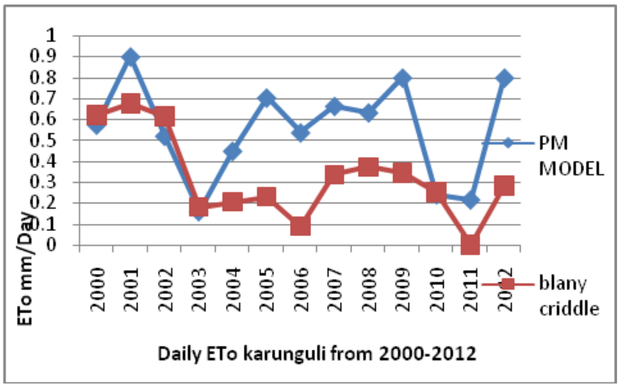

Fig.4. Performance of ETo model PM-model vs Blaney-Criddle method

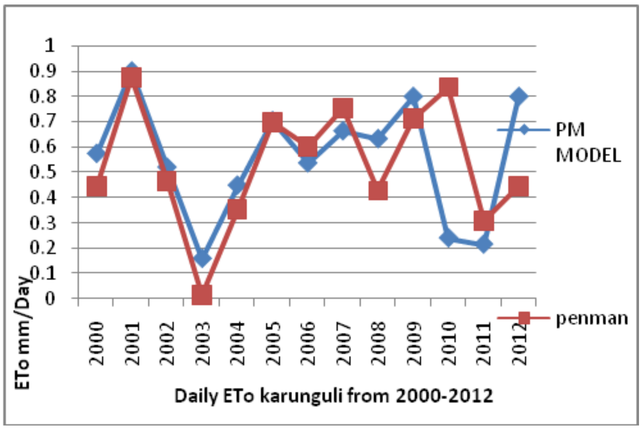

Fig.5. Performance OF ETo models PM-model VS Penman method

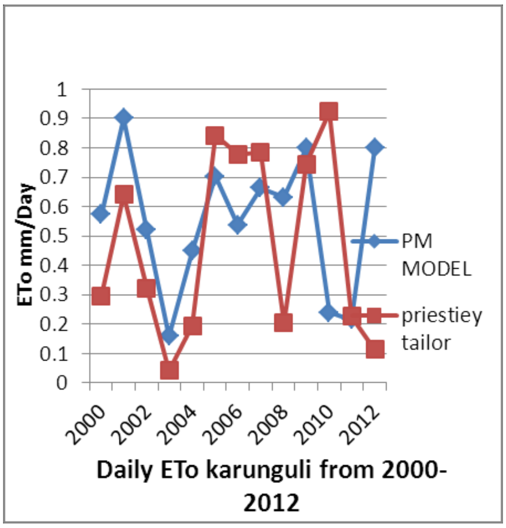

Fig.6.Performance ETo model PM-model VS Priestley-Tailor method

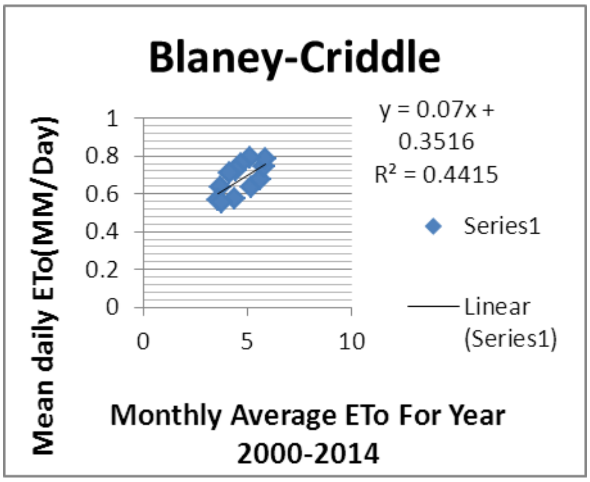

Fig.8. Monthly average Estimated Billany-Criddle model ETo for year 2000-2012

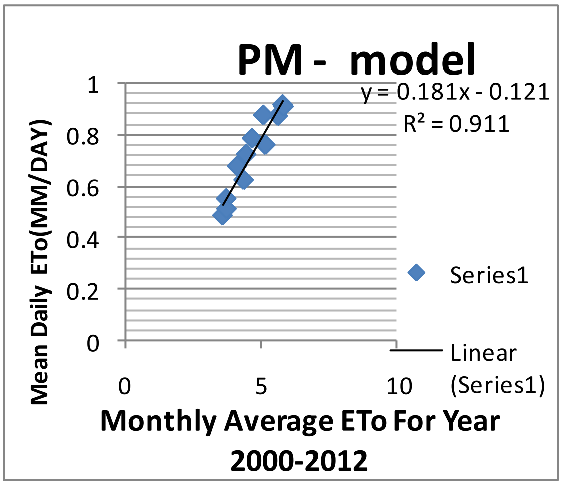

Fig.7. Monthly average Etimated PM-modle ETo for year 2000-2012

Figure 7 shows the Regression between the original parameter (observed pan evaporation data)and estimated (Penman Monteith method) these value got 91% is correlated this is not expected. This result shows the evaporation occur properly.

A Figure 8 show the R^2 value is 0.4 is below example40% is achieved. So there is not a correlation between the original data (Pan evaporation) and Blaney-Criddle method. so not fitted with this model.

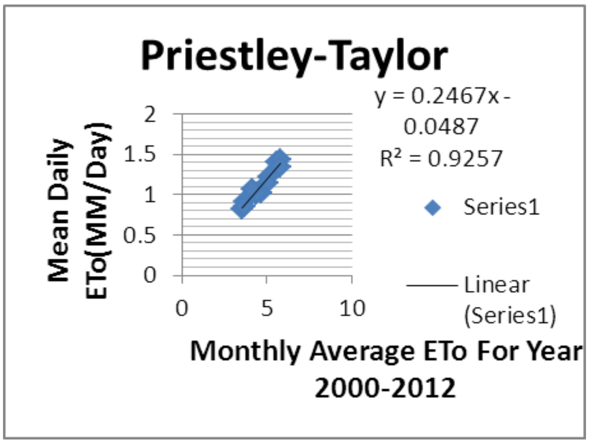

Fig.9. Monthly average Estimated Priestly –Taylor model ETo for year 2000-2012

Figure 9 shows the R^2 value 0.92 so it fitted very closure to the original parameter for (pan-evaporation) it is the good correlation were observed.

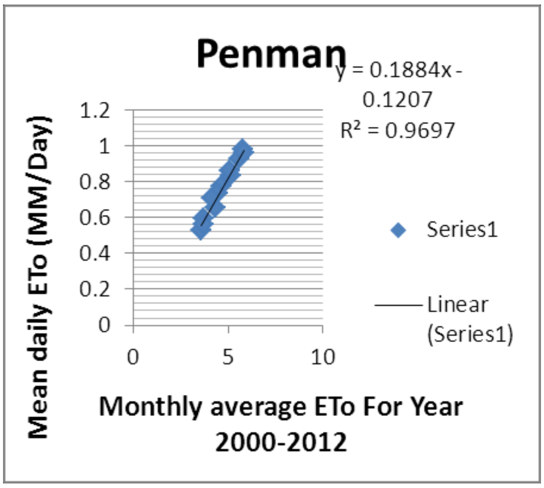

Fig.10. Monthly average Estimated Penman model ETo for year 2000-2012

Figure 10 shows the R^2 value 0.96 with original parameter (pan evaporation) with Penman Method. This method is more fitted to this location. This indicates gradually corrected to the environment.

A. Recalibration of constants

Case: 1

Mean annual ETo was computed using selected models with original constant, and that of standard Penman-Monteith model for a given location. Percent error in mean annual ETo computed between selected any one model and that of Penman-Monteith model for a given location was found. Correction equivalent to percent error was applied to the values of mean daily ETo computed by selected any one model. The models considered for evaluation are empirical in nature. But the PM model is physically based. Therefore the ETo estimated by the models considered are bound to have some extreme values and to smoothen the extreme values, a correction is applied. The correction is estimated assuming that the annual total ETo of any one model should be closer to the annual ETo of PM model. After the correction the result obtained was referred as ETo (adjusted). It is then equated to the expression of the respective model and the new constant was found. the year and hence for the period (2000 – 2012) was found for each model. The mean of the most frequently occurring values was taken as the recalibrated constant of any one model. This step was followed for other selected models.

Case: 2

Assuming that percentage error between daily ETo computed by any one model and Penman-Monteith model was zero, the constants involved in each model other than Penman-Monteith model was recalibrated as described in Case 1.

Case: 3

Mean annual ETo computed by any one model from different locations were related to corresponding mean annual ETo computed by Penman-Monteith model by Linear regression. For any one selected model mean annual ETo was computed .This is related to the corresponding mean annual ETo of Penman-Monteith model of Kancheepuram by linear regression. The linear regression line was of the form

$$Y = c + mX$$

where

Y represents ETo of Penman-Monteith model, X represents ETo of anyone model and c and m are constants (regression). From the linear regression line equation, the intercept value 'c' and slope 'm' are obtained. In the equation substituting the values of 'c' and 'm' and Xi values (Mean daily ETo estimated by any one model), the value of 'Y' on daily basis is computed. This is referred as ETo (adjusted). Equating this value with respective equation of the X and inputting the daily meteorological variables of the equation X, the constant is calculated for all days of a year. The average for a year and for the period is computed for each model and for all locations. The constant value that has to represent the composite region of Kancheepuram District was worked out as described in case.

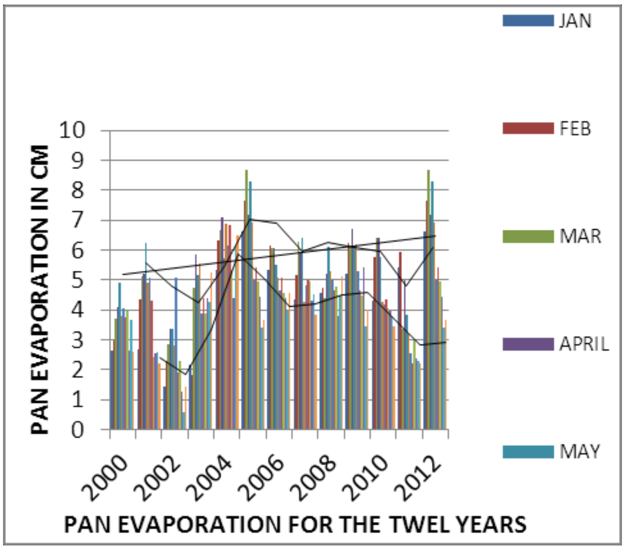

Fig.11. Overall Comparison for Pan Evaporation (Observed) for 2000-2012

Figure 11 shows graph shows the daily ETo for month wise 2000-2012 it shows April, may, June for the 13 years is shows the maximum (or) peak value and Nov, Dec, Jan shows the minimum value.

V. CONCLUSION

From the investigation for total 13 years the graph is gradually increasing which denotes the increase in pan evaporation parameter due to the reason of sol air increase, inadequate rainfall and de-forestation is the reason for the Linear line increase Climate change is already affecting agriculture, with effects unevenly distributed across the world. Future climate change will likely negatively affect crop production in low latitude countries, while effects in northern latitudes may be positive or negative, by using this different modeling technique. Climate change will probably increase the risk of food insecurity for some vulnerable groups. The international aspect of trade and security in terms of food implies the need to also consider the effects of climate change on a global scale.

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