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Temperature-Based Analysis of Reference Evapotranspiration Models for the Distributary D-17 of TLBC Command Area, Raichur

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ABSTRACT

Evapotranspiration (ET) is the simultaneous process of transfer of water to the atmosphere by transpiration and evaporation in a soil–plant system. ET is an important parameter for climatological and hydrological studies, as well as for irrigation planning and management. The present study aims to determine the best model under temperature-based models for the distributary, D-17 of TLBC command area. For this purpose, daily meteorological data for the period from 2018 to 2022 was collected used for the estimation of reference evapotranspiration by six different temperature-based models and compared with the FAO Penman–Monteith model. The best fit model was selected based on the less MAE and high R^2 value for *rabi* and *kharif* season. The results revealed that, the Linacre model shows the least MAE with higher frequency and high R^2 value during the *rabi* and *kharif* season in the study period 2018-2022, the results indicated that, the Linacre model can be used to estimate the ET_o for distributary, D-17 when the available weather data is limited.

Keywords Evapotranspiration, FAO-56 Penman–Monteith, Temperature-based model, Distributary D-17, TLBC command area.

INTRODUCTION

Evapotranspiration (ET), is the sum of transpiration through plant canopy and evaporation from soil, plant, and open water surface which is the largest and dominating component of the hydrologic cycle due to the fact that 60% of annual precipitation falling over the land surface is returned to atmosphere as Evapotranspiration (ET). Under the semi-arid or arid climatic conditions coupled with low and erratic rainfall, water is the most limiting factor for agricultural productivity and irrigation planning. Evapotranspiration is estimated as a two-step process, the evaporative demand of the environment is estimated based on weather conditions and is often estimated as the

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evapotranspiration from a theoretical, reference grass crop (ET_o) with the crop defined as an actively growing, uniform surface of grass, completely shading the ground, and not short of water (Doorenbos and Pruitt 1977). The ET_o value is then adjusted to estimate the evapotranspiration of the particular crop of interest using a crop-specific crop coefficient.

High precision measurements of actual evapotranspiration are obtained using lysimeter or imaging techniques, the costs of which are very high. Instead, researchers use crop co-efficient and reference evapotranspiration values to calculate actual evapotranspiration. Thus, the Food and Agriculture Organization of the United Nations (FAO) Penman–Monteith model (Allen *et al.* 1998) has been replaced with better models to estimate evapotranspiration. Although the FAO Penman-Monteith model has been applied in various regions of the world it needs too many parameters to estimate evapotranspiration (Valipour 2015a).

In most of the region, weather data is the limiting factor in most of the regions and researchers cannot use the Penman-Monteith model. Hence, experimental models have been developed for the estimation of evapotranspiration using limited data. They include models based on mass transfer, radiation, temperature and pan evaporation. Improved techniques are needed for accurate quantification of ET on a field, watershed and regional scale to enhance efficient use of water resources and sustainability of agro-ecosystem productivity and protect the environment and water quality. The temperature-based model is one of the most widely used models to estimate evapotranspiration. Common temperature-based models are Linacre, Hargreaves-Samani, Berti, Baier-Robertson models. Suchita and Krishnamurthy (2018) estimated and compared the four temperature-based models using the weather data of GKVK station. The recent studies for the semiarid regions estimated the ET_o using advanced models such as CROPWAT (Reddy *et al*. 2020).

This present study aims to estimate the evapotranspiration for distributary D-17 of Tungabhadra left bank canal command area using the daily weather data using six different temperature-based models (Linacre, Hargreaves-Samani, Berti, Baier-Robertson and two modified Hargraves-Samani models) and compared with the Penman-Monteith model to find the best fit model for D-17 during *rabi* and *kharif* season.

MATERIALS AND METHODS

The present research work was conducted on the Tungabhadra Left Bank Canal (TLBC) command area which is major distributary canal serves the irrigation and drinking water supply to twin districts Karnataka and Andhra Pradesh constructed on the River Tungabhadra. The river Tungabhadra derives its name from the Tunga, and the Bhadra, formed by the confluence of two rivers. Tungabhadra irrigation project is an inter-state multipurpose project which is constructed across the Tungabhadra River at Mallapur village about 5 kms from Hospet town, Vijayanagar district, Karnataka.

Tungabhadra Left Bank Canal (TLBC) command area which lies from 15° 15.50’ 46” N, 76° 19’ 43” E and 16° 10.27’ 26” N, 77° 19’ 50” N at an elevation of 402-516 m from mean sea level. The irrigation water is supplied from the Tungabhadra dam through 227 km long main canal to 106 distributaries having the total command area of 244,000 ha. This paper focussed on distributary number 17 (D-17) of Tungabhadra Left Bank Canal (TLBC) command area which lies between 76° 28’ 4.53” E and 15° 26’ 36.40” N at an elevation of 419-466 m above the mean sea level. The Distributary D-17 takes off from main canal at 47 kms from reservoir, gets divided into three branches and has a length of 15.97 kms with 36 Pipe Outlets. The D-17 is adjacent to Gangavathi town of Koppal district falls in the head reach area with abundant of water supply for *Kharif* season and experiences shortfall of water for *Rabi* season. First half of the head reach area of the distributary command is with sandy loam soils and rest is black soil. The D-17 has a culturable command area of 3,955.08 ha, Paddy is the dominating crop in both *kharif* and *rabi* seasons.

Daily weather data for the study period from 2018 to 2022 was collected from the Karnataka State Natural Disaster Monitoring Center (KSNDMC) and the five years average weather parameters were calculated (Table 1) for D-17 of TLBC command area and

Table 1. Daily average meteorological parameters for distributary D-17 (2018-2022).

Parameter Month	T_{max} (°C)	T_{min} (°C)	T_{mean} (°C)	RH (%)	Wind speed ($m\ s^{-1}$)	Cum RF (mm)
Jan	31.03	17.99	24.51	64.53	1.40	6.29
Feb	32.75	18.76	25.75	58.63	1.31	3.09
Mar	36.40	21.40	28.90	55.72	1.39	4.49
Apr	38.97	24.48	31.72	52.68	2.25	40.68
May	38.85	25.61	32.23	56.21	3.03	83.03
Jun	34.85	24.62	29.73	67.97	2.63	81.00
Jul	31.90	23.96	27.93	74.81	2.47	119.81
Aug	31.33	24.05	27.69	77.66	2.03	101.65
Sep	31.58	23.21	27.39	76.51	1.57	144.96
Oct	32.43	22.08	27.25	74.55	1.48	118.19
Nov	30.58	19.74	25.16	72.16	1.58	27.47
Dec	30.32	18.06	24.19	70.76	1.48	6.76

used to estimate the ET_o using six temperature-based models such as Hargreaves-Samani (H-S) equation, Linacre, two modified Hargreaves-Samani equations (HM-1, HM-2), Berti and Baier-Robertson models.

The standard FAO-56 Penman-Monteith model for estimating the ET_o is expressed as (Allen *et al.* 1998)

$$ET_o = \frac{0.408\Delta\,(R_n - G) + Y\,\frac{900}{(T+273)}U_2\,(e_s - e_a)}{\Delta + Y\,(1+0.34\,U_2)} \qquad \text{--- (1)}$$

Where,
ET_o = reference evapotranspiration [mm day^{-1}]
R_n = net radiation at crop surface [MJ m^{-2} day^{-1}]
G = soil heat flux [MJ m^{-2} day^{-1}]
T = average temperature at 2 m height (°C)
T_d = dew point temperature (°C)
U_2 = windspeed measured at 2 m height [m s^{-1}]
(e_s-e_a) = vapour pressure deficit for measurement at 2 m height [k Pa]
Δ = slope vapour pressure curve [k pa °C^{-1}]
γ = psychrometric constant [k pa °C^{-1}]
900=coefficient for the reference crop [l J^{-1} kg K day^{-1}]
0.34 = wind coefficient for the reference crop [s m^{-1}]
Z = elevation (m)

Linacre equation

A method that is similar in concept to the original Penman is the Linacre model. This model was designed to calculate lake evaporation and evapotranspiration in areas with limited climatic data while still using the physical concepts that enable the Penman family of models to be generally regarded as the most accurate (Linacre 1977). Linacre's model requires slightly more data than that required by other limited data models such as Hargreaves-Samani, but significantly less than is needed by the Penman models. The initial equation derived by Linacre (1977) for grass-reference evapotranspiration in1977 for a well-watered vegetation with an albedo of 0.25 which is actually a simplification of Penman formula and is expressed as:

$$ET_o = \frac{\frac{500\ Tm}{(100\text{-}A)} + 15\,(T_a - T_d)}{(80 - T_a)}$$

Where,

T_m = T+0.006h (ºC)
H= elevation (m)
A = latitude (radian)
T_d = mean dew temperature (ºC)
T_a = mean air temperature (ºC)

Hargreaves-Samani (H-S) equation

The Hargreaves-Samani (H-S) 1985 model is one of the more represent versions of one of the older evapotranspiration models (Hargreaves and Allen 2003). The H-S model used in this study has conceptually similar versions (Hargreaves and Samani 1985), which intended to be computationally simple and applicable to a variety of climates using only commonly available meteorological data. The creation of the H-S model used in this study was intended to simplify the previous versions further by reducing the amount of measured meteorological data to air temperature and by using extraterrestrial radiation (R_a) as a substitute for measured sunshine or radiation data (Hargreaves and Allen 2003). The H-S model was later adopted for used by the FAO for areas where air temperature alone is the only available variable (Allen *et al.* 1998, Hargreaves and Allen 2003). The form of the H-S equation presented in FAO 56 by Allen *et al.* (1998) is:

$$ET_0 = 0.0023\,(T_{mean} + 17.8)\,(T_{max} - T_{min})^{0.5}\,R_a \qquad .....(3)$$

Where,

R_a = extra-terrestrial radiation (mm day^{-1})
T_{max} = the daily maximum temperature (°C)
T_{min} = the daily minimum temperature (°C)
T_{mean} = the daily mean temperature (°C)

Droogers and Allen (2002) reported two new types of the Hargreaves equation (Hargreaves and Samani 1985) as follows:

$$ET_o = 0.408 \times 0.0030 \times (T_a + 20) \times (T_{max} - T_{min})^{0.4} \times R_a \text{ (HM-1)} \quad \text{.... (4)}$$

$$ET_o = 0.408 \times 0.0025 \times (T_a + 16.8) \times (T_{max} - T_{min})^{0.5} \times R_a \text{ (HM-2)} \quad \text{.... (5)}$$

Where,

ET_o is in mm day^{-1} and P is monthly rainfall (mm), the coefficient of 0.408 is for converting MJ m^{-2} day^{-1} into mm day^{-1}.

Note: Since the eq. 5 was developed for humid climate region, hence this was not used in the present study.

Berti equation

Berti *et al.* (2014) developed an ET_o equation for plain areas of north-eastern Italy. He made regional calibration for the Hargreaves equation. The equation is based on average, minimum and maximum air temperature and extraterrestrial radiation and given as,

$$ET_o = 0.408 \times 0.00193 \times (T_a + 17.8) \times (T_{max} - T_{min})^{0.517} \times R_a \quad \text{...(7)}$$

Baier and Robertson equation

The original Baier Robertson equation was developed from, and calibrated with five-year climatological records taken from six agricultural research establishments across Canada (Baier and Robertson 1965). This equation was one of the first to express solar radiation effects on ET as a function of upper atmospheric extra-terrestrial radiation (R_a) and daily maximum and minimum temperatures (Rochette *et al.* 1990).

$$ETo = 0.157T_{max} + 0.158T_D + (0.109R_a - 5.39) \quad \text{......(8)}$$

The performance of these methods was tested using the statistical tests using following equations.

Mean absolute error (MAE)

The criteria of the residual standard deviation and should be as small as possible (optimally zero)

$$MAE = \frac{\sum_{i=1}^{n} (P_i - O_i)}{n} \quad \text{......(9)}$$

Coefficient of determination (R^2)

The coefficient of determination is the squared value of the coefficient of correlation and measures the degree dispersion to which two variables are linearly related. The R^2 value ranged from 0 (no correlation) to 1 (estimated dispersion is equal to observed dispersion)

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (O_i - P_i)}{\sum_{i=1}^{N} \left(O_i \frac{\sum_{i=1}^{N} O_i}{N} \right)} \quad \text{......(10)}$$

Where,

i= indicates month,
P_i = estimated ET_o by different empirical model,
O_i = estimated ET_o by Penman-Monteith model and
n = total number of months

RESULTS AND DISCUSSION

Daily analysis results of reference evapotranspiration

The daily average ET_o for the study period 2018 to 2022 was estimated from the Penman-Monteith model for distributary D-17 of TLBC command were analyzed statistically and statistical parameters like mean, maximum, minimum, standard deviation (SD) and coefficient of variance (CV) are presented in Table 2. The results revealed that, the mean minimum and maximum ET_o was 4.03 (2021) and 6.56 mm day^{-1} (2019) respectively. The SD varied from 1.08 to 2.24 mm day^{-1}. The CV varied from 26.49 to 35.76%. The results indicated that, more than 10.00 mm of ET_o was observed during the year 2019 (April and May) month whereas the least was in the year 2022. The

Table 2. Daily average ET_o parameters in mm from Penman-Monteith method in distributary, D-17.

Month	2018	2019	2020	2021	2022
Jan	2.82	4.82	4.32	3.94	3.11
Feb	3.26	6.21	4.73	4.40	3.42
Mar	5.47	7.39	5.16	4.82	4.43
Apr	8.83	10.23	6.71	6.68	5.57
May	9.77	10.28	8.97	6.56	6.38
Jun	7.33	8.64	6.26	5.10	5.01
Jul	6.36	7.10	5.47	4.49	3.58
Aug	5.32	6.14	4.64	4.01	3.51
Sep	6.04	5.40	4.29	3.06	3.43
Oct	5.17	4.76	4.08	3.07	3.33
Nov	4.59	4.21	3.69	2.73	3.35
Dec	4.44	3.49	3.70	2.38	3.19
Max	9.77	10.28	8.97	6.68	6.38
Min	2.82	3.49	3.69	2.38	3.11
Mean	5.78	6.56	5.17	4.27	4.03
SD	2.07	2.24	1.52	1.39	1.08
CV (%)	35.76	34.24	29.49	32.44	26.69

average ET_o was increased from in the year 2019 and shows the decreasing trend from 2020 to 2022. This, accounts to the change of climatic parameters and occurrence of rainfall during the respective years.

Monthly analysis results of ET_o from temperature-based models for D-17 in *rabi* season

The monthly analysis was carried out for the *rabi* (December to March) and *kharif* (July to November) months by using daily average ET_o estimated from six different temperature-based models for the distributary D-17 of TLBC command area. Each model was compared with the FAO-56 Penman-Monteith model using MAE and regression. The results of statistical distribution of six temperature-based ET_o models are presented for *rabi* and *kharif* season for study period from 2018 to 2022 and respective results obtained from the statistical analysis are tabulated in the Tables.

Table 3. Mean monthly ET_o from temperature-based models during *rabi* (2018-2022).

Rabi	PM	Linacre	H-S	HM-1	HM-2	Berti	Baier-Robertson
Dec	3.30	4.13	3.87	4.14	4.11	3.39	4.39
Jan	3.80	4.38	4.19	4.45	4.45	3.68	4.75
Feb	4.40	4.94	4.95	5.21	5.26	4.35	5.50
Mar	5.46	5.74	6.05	6.30	6.43	5.31	6.60
Mean	4.24	4.80	4.77	5.03	5.06	4.18	5.31
SD	0.93	0.71	0.97	0.96	1.03	0.85	0.98
SEE	-	-13.09	-12.43	-18.54	-19.42	1.36	-25.27

The monthly distribution of daily average ET_o from six temperature-based models for *rabi* 2018-2022 is given in Table 3. The results show that, the estimated average monthly ET_o from six temperature-based models varied from 3.39 to 4.39 mm day^{-1} in December, 3.68 to 4.75 mm day^{-1} in January, 4.35 to 5.50 mm day^{-1} in February and 5.31 to 6.60 mm day^{-1} in March respectively. The seasonal mean ET_o

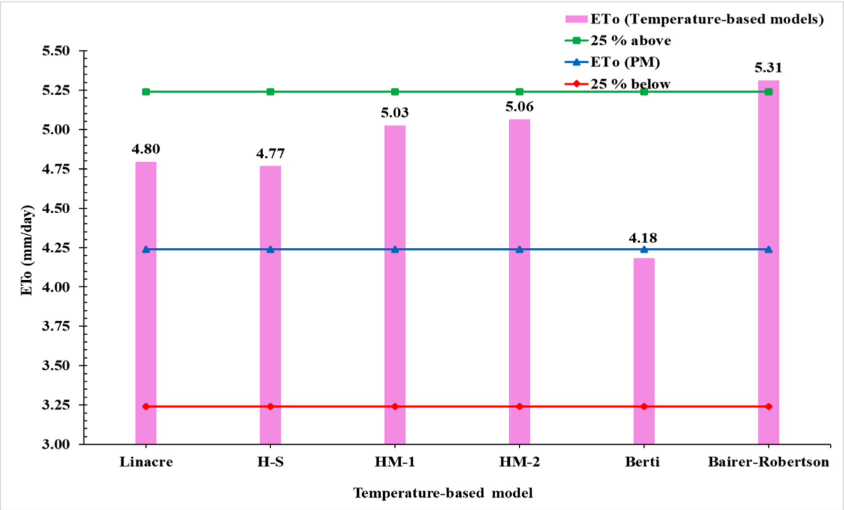

Fig. 1. Monthly mean distribution of daily average ET_o from temperature-based models in D-17 during *rabi* (2018-2022).

varied from 4.18 to 5.31 mm day^{-1} standard deviation ranged from 0.71 to 1.03 mm day^{-1}. The Berti model estimated the lowest ET$_o$ value (3.39 mm day^{-1}) in December and shows the minimum deviation from the mean with positive SEE of 1.36. In contrast, the Baier-Robertson estimated highest ET$_o$ value (6.60 mm day^{-1}) and resulted in maximum deviation with maximum negative SEE of -25.27.

The mean ETo estimated from the Penman-Monteith and six temperature-based models and 25 percentage of deviation on the higher and lower side of the mean ET$_o$ from the Penman-Monteith model is presented in Fig. 1. The results show that, the mean ET$_o$ estimated from the temperature-based models was more than mean ETo from the PM model except Berti model which gave lesser ET$_o$ than the PM, however the estimated mean ET$_o$ from Berti model (4.18 mm day^{-1}) was very closer to the PM model ET$_o$ (4.24 mm day^{-1}). Baier-Robertson model shows highest deviation which falls above the 25% from the mean ET$_o$ and lesser deviation in mean ET$_o$ was observed by the H-S and Linacre models.

The statistical performance of daily average ET$_o$ from six temperature-based models for *Rabi* season from 2018 to 2022 is given Table 4. The results reveal that, Linacre and Berti models show MAE greater than 1.00 mm day^{-1} once in five-year study period and the other four models viz., H-S, HM-1, HM-2 and Baier-Robertson models show MAE greater than 1.00 mm day^{-1} twice during the study period 2018-2022. The least average MAE of 0.65 for the five-year study period during *Rabi* season was given by the Linacre model with R^2 value of 0.90 followed by Berti model with MAE and R^2 value of 0.70 mm day^{-1} and 0.95. The least MAE was observed by the Linacre model whereas the highest R^2 was observed with the Berti model, and the monthly distribution of daily average ET$_o$ from six temperature-based models for *Rabi* 2018-22 shows that, Berti model slightly underestimated and yielded ET$_o$ closest to the PM model with SD of 0.85 mm day^{-1} and positive standard error of estimation (1.36 mm day^{-1}), hence the results indicated that, Berti model is the best fit model from the estimation of ET$_o$-during *Rabi* season for the distributary D-17 of TLBC command area.

Table 4. Statistical performance of temperature-based models in D-17 during *rabi* 2018-2022.

Rabi year	Linacre	H-S	HM-1	HM-2	Berti	Baier-Robertson
			Mean absolute error MAE (mm day^{-1})			
2017-18	1.58	1.49	1.71	1.80	0.89	2.11
2018-19	0.28	0.59	0.36	0.26	1.21	0.18
2019-20	0.26	0.21	0.29	0.65	0.33	0.36
2020-21	0.33	0.43	0.63	0.84	0.38	0.86
2021-22	0.79	1.24	1.52	1.52	0.68	1.72
Mean	**0.65**	**0.79**	**0.90**	**1.02**	**0.70**	**1.05**
			Co-efficient of determination R^2			
2018-19	0.64	0.68	0.58	0.53	0.89	0.36
2019-20	1.00	0.98	0.99	1.00	0.92	1.00
2020-21	0.99	1.00	0.99	0.96	0.99	0.99
2021-22	0.99	0.98	0.96	0.93	0.99	0.93
2022-23	0.90	0.85	0.78	0.78	0.96	0.72
Mean	**0.90**	**0.90**	**0.86**	**0.84**	**0.95**	**0.80**

Monthly analysis results of ET$_o$ from temperature-based models for D-17 in *kharif* season

The monthly distribution of daily average ET$_o$ from six temperature-based models for *kharif* months from July to November during the study period 2018 to 2022 is tabulated in Table 5. The results show that, the estimated average monthly ET$_o$ from six temperature-based models varied from 4.00 to 5.12 mm day^{-1} in July, 3.76 to 4.86 mm day^{-1} in August, 3.86 to 4.90 mm day^{-1} in September 3.92 to 4.96 mm day^{-1} in October and 3.43 to 4.39 mm day^{-1} in November respectively. The seasonal mean ET$_o$ varied from 3.74 to 4.76 mm day^{-1} standard deviation ranged from 0.09 to 0.32 mm day^{-1}. The Berti model estimated the

Table 5. Mean monthly ET$_o$ from temperature-based models during *kharif* (2018-2022).

Months	PM	Linacre	H-S	HM-1	HM-2	Berti	Baier-Robertson
Jul	5.40	4.42	4.61	5.12	4.90	4.00	5.05
Aug	4.72	4.20	4.33	4.86	4.61	3.76	4.82
Sep	4.44	4.22	4.43	4.90	4.71	3.86	4.85
Oct	4.08	4.31	4.49	4.87	4.77	3.92	4.96
Nov	3.72	4.08	3.93	4.25	4.17	3.43	4.39
Mean	4.47	4.20	4.30	4.72	4.57	3.74	4.76
SD	0.64	0.09	0.25	0.32	0.27	0.22	0.25
SEE	-	6.04	3.94	-5.49	-2.08	16.31	-6.31

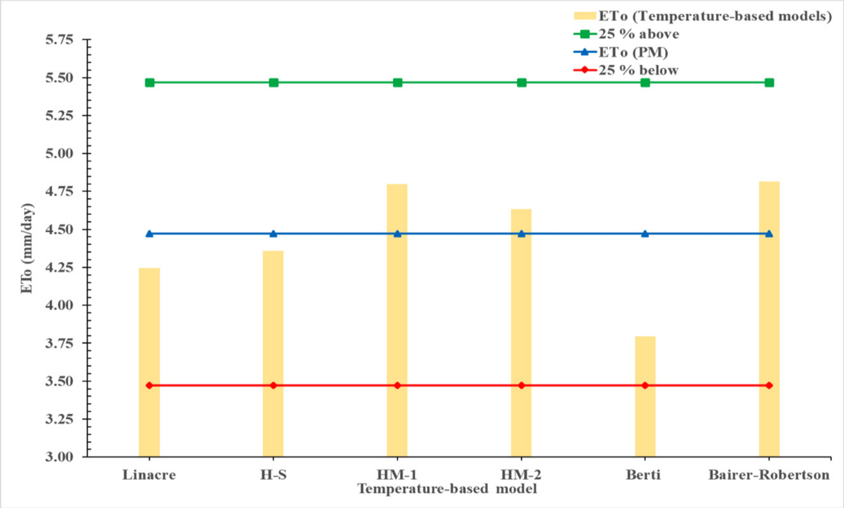

Fig. 2. Monthly mean distribution of daily average ET_o from temperature-based models in D-17 during *kharif* (2018-2022).

lowest ET_o value (3.43 mm day^{-1}) in November while HM-1 model estimated highest ET_o value (5.12 mm day^{-1}) in July. The H-S and Baier-Robertson models show the minimum positive and maximum negative SEE of 3.94 and 6.31 respectively.

The mean ET_o estimated from the Penman-Monteith and six temperature-based models and 25 percentage of deviation on the higher and lower side of the mean ET_o from the Penman-Monteith model is presented in Fig. 2. The results show that, the mean ET_o estimated from the three models HM-1, HM-2 and Baire-Robertson models was more than mean ET_o from the PM model and the mean ET_o estimated from Linacre, H-S and Berti models was less than mean ET_o from the PM model. However, H-S and HM-2 models yields the ET_o values closer to the ET_o value estimated from Penman-Monteith method.

Table 6. Statistical performance of temperature-based models in D-17 during *kharif* 2018-2022.

Kharif year	Linacre	H-S	HM-1	HM-2	Berti	Baier-Robertson
			MAE (mm day^{-1})			
2017-18	0.67	0.79	0.52	0.64	1.37	0.66
2018-19	0.95	1.22	0.77	0.95	1.78	0.80
2019-20	0.27	0.19	0.14	0.82	0.22	0.22
2020-21	0.63	0.81	1.22	1.04	0.49	1.17
2021-22	0.13	0.83	1.27	1.10	0.28	1.28
Mean	0.53	0.77	0.78	0.91	0.83	0.82
			R^2			
2018-19	0.98	0.97	0.99	0.98	0.90	0.98
2019-20	0.95	0.92	0.97	0.95	0.84	0.97
2020-21	0.99	1.00	1.00	0.96	1.00	1.00
2021-22	0.95	0.97	0.92	0.94	0.99	0.93
2022-23	1.00	0.91	0.79	0.84	0.99	0.79
Mean	0.97	0.95	0.93	0.94	0.94	0.93

The statistical performance of daily average ET_o from six temperature-based models for *kharif* season from 2018 to 2022 is given Table 6. The results reveal that, Linacre shows MAE less than 1.00 mm day^{-1} throughout the study period, H-S model gave MAE greater than 1.00 mm day^{-1} once and four models HM-1, HM-2, Berti and Baier-Robertson model yields twice in five-year study period. The least average MAE of 0.53 mm day^{-1} was observed by the Linacre model with R^2 value of 0.97 followed by H-S model with MAE and R^2 value of 0.77 mm day^{-1} and 0.95. The results indicated that, Linacre model is the best fit model from the estimation of ET_o during *kharif* season for the distributary D-17 of TLBC command area. Many comparison studies have confirmed that this model can be used to calculate ET_o if the full weather datasets were not available in arid and semi-arid regions. Singh *et al.* (2022) reported Hargreaves model performs best in estimating the ET_o with the R^2 value of 0.99 in temperature-based models for the research region in the Gaya District, Bihar.

CONCLUSION

In the present study, six temperature-based models were employed to estimate the evapotranspiration in D-17 distributary of TLBC canal command area, Raichur, Karnataka. In summary, the precision of estimates by temperature-based models is very sensitive to the variations of the parameters used in each model. Thus, researchers must use them according to the best weather conditions. The best values of R^2 were 0.96 in *rabi* and 0.95 in *kharif* season for the Linacre model. The research finding indicated that, the Lincare model is the best model to estimate the ET_o when the weather data is limited or restricted to only the air temperature, as the model can provide the reasonably good estimates of ET_o values when compared with the Penman-Monteith model. The findings of the present study are useful not only for distributary D-17 but also for all the regions in the world based on the best ranges of each weather parameter that are applicable for similar climatic conditions.

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REFERENCES

Allen RG, Pereira LS, Raes D, Smith M (1998) Crop evapotranspiration Guidelines for computing crop water requirements. FAO Irrigation and Drainage, Paper No 56 FAO Rome.

Baier W, Robertson GW (1965) Estimation of latent evaporation from simple weather observations. *Canadian Journal of Plant Sciences* 45: 276-284.

Berti A, Tardivoa G, Chiaudani A, Rech F, Borin M (2014) Assessing reference evapotranspiration by the Hargreaves method in north-eastern Italy. *Agriculture Water Management* 140: 20-25.

Doorenbos J, Pruitt W (1977) Crop water requirements. Irrigation and Drainage Paper 24, Food and Agriculture Organization of the United Nations, Rome, pp 144.

Droogers P, Allen RG (2002) Estimating reference evapotranspiration under imprecise data conditions. *Irrigation and Drainage System* 16: 33-45.

Hargreaves GH, Allen RG (2003) History and evaluation of Hargreaves evapotranspiration equation. *Journal of Irrigation and Drainage Engineering* 1 (53): 53-63.

Hargreaves GL, Samani ZA (1985) Evapotranspiration from temperature *Applied Engineering in Agriculture* 1 (2): 96-99.

Linacre ET (1977) A simple formula for estimating evaporation rates in various climates using temperature data alone. *Agricultural Meteorology* 18 : 409-424.

Reddy M, Ganachari A, Lokesh K (2020) Estimation of reference evapotranspiration using CROPWAT model at Raichur region Karnataka. *The Pharma Innovation Journal* 9(5) : 226-231.

Rochette P, Fillion G, Mattei J, Dekkers MJ (1990) Magnetic transition at 30-34 Kelvin in pyrrhotite, insight into a widespread occurrence of this mineral in rocks. *Earth and Planetary Science Letters* 98 (3-4) : 319-328.

Singh I, Mishra AK, Suryavanshi S (2022) Comparison of different methods in estimating reference evapotranspiration at Gaya District of Bihar India. *International Journal of Environment and Climate Change* 12(12) : 1149-1157.

Suchita P Kalekar, Krishnamurthy KN (2018) Comparison of temperature based reference evapotranspiration methods with FAO 56 Penman-Monteith method. *Mysore Journal Agricultural Sciences* 52 (1): 12-17.

Valipour M (2015a) Temperature analysis of reference evapotranspiration models. *Meteorological Applications* 22 (1) : 385–394.