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Estimating reference evapotranspiration using CROPWAT model at Raichur region Karnataka

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Abstract

This paper estimate reference crop Evapotranspiration in Raichur region Karnataka using CROPWAT model. Determination of Evapotranspiration (ET) is important in application such as irrigation design, irrigation scheduling, water resource management, hydrology and cropping systems modeling. The penman montieth formulation is regarded as a good estimator for a wide variety of climatic conditions. The United Nations food agriculture organization (FAO) adopted the P-M method as global standard to estimate reference crop (ETo) from meteorological data. Based on the intensive study of this paper, monthly meteorological weather data recorded from 2013 to 2014 were used to obtain the result. The ETo data were calculated for each parameter and the obtained results were compared. Reference crop Evapotranspiration (ETo) and monthly effective rainfall was calculated using CROPWAT model. The study detects that penman – montieth is the best method to estimate ETo because of its inclusion of parameters in calculation.

Keywords: Evapotranspiration (ET_O), CROPWAT, climatic parameters penman-montieth

Introduction

The estimate of reference crop Evapotranspiration is an important in irrigation and agriculture water research, management and development. The general knowledge of the spatial distribution of reference Evapotranspiration, (ETo) is still sketchy despite its importance for global ecosystem research. One reason is that ETo is difficult to observe directly as it depends on several meteorological parameters which are observed only at major stations.

The first step in this paper consider the effect of climate by calculating the reference crop Evapotranspiration (ETo) which is define in FAO-24 as “the rate of Evapotranspiration from an extensive surface of 8 to 15 cm tall, green grass cover of uniform height, activity growing, completely shading the ground and not short of water”.

To estimate reference crop Evapotranspiration (ETo) from meteorological data require daily maximum and minimum temperature, relative humidity, wind speed and solar radiation and sunshine duration.

The objective of this study was to utilize climate data sets at Raichur region for the 2013-2014 periods to calculate reference crop Evapotranspiration by CROPWAT model. This paper provides a summary of the review of the various ET0 methods presents the new recommended standard of the FAO penman- montieth methods as consistent and globally valid standard for reference crop Evapotranspiration and crop water requirement calculations and indicates how to apply the method when limited climatic data are available. A large number of empirical methods have been developed to estimate Evapotranspiration from different climate variables. Based on the available research results and recommendations of expert consultations, four Evapotranspiration methods were adopted in the FAO No-24 method to be used according the availability of climatic data, and also we add Advantages and Disadvantages as indicated in Table 1:

The FAO computer program Cowpat utilize the penman-montieth method and spread sheet also available from FAO to calculate reference crop evaporation. it’s used in this study.

Study area

The study was conducted in Main Agricultural Research Station, UAS Raichur in Karnataka 16˚15' N latitude and 77˚20' E longitude and is at an elevation of 389 m above mean sea level (MSL).

Software used

A model based on CROPWAT model for irrigation planning and management was used.

It is support system designed a tool to help meteorologists and irrigation engineers carry out standard calculation for Evapotranspiration and crop water use studies. The Reference Evapotranspiration (ETo) represents the potential evaporation of a well-watered grass crop. The water needs of other crops are directly linked to this climatic parameter.

Although several methods exist to determine ETo, the Penman Montieth Method has been recommended as the appropriate combination method to determine ETo from climatic data on:

- Temperature
- Humidity
- Sunshine
- Wind speed.

Climate data collection

In order to calculate ETo, the respective climatic data should be collected from the nearest and most representative meteorological station. Several institutes and agencies may keep climatic records such as the Irrigation Department, the Meteorological Service or nearby Agricultural Research Stations and may provide information on climatic stations inside or in the vicinity of our irrigation scheme which should be considered for crop water requirement (CWR) calculations. In some cases, when the scheme is large, more than one station may be available, but often no suitable stations with sufficient climatic data are located in the scheme. In such a case a careful selection should be made of the data. In our example, the data for the Research Scheme have been obtained from the Following source: Metrology station Main Agricultural Research Station, UAS, Raichur. For the 2013-2014 periods for the following parameters: Rainfall, Minimum and Maximum temperature, humidity, wind speed, sunshine hours, calculation were done using the mean value of each parameter.

The module is primary for data input, requiring information on the meteorological station (country, name, altitude, latitude and longitude) together with climatic data. CROPWAT 8.0 can calculate reference ETo using only temperature, but humidity, wind speed and sunshine should be entered if available.

The Climate/ET_0 module includes calculations, producing Radiation and ET_0 data using the FAO Penman-Montieth approach. A printout of climatic data inserted and of calculated Radiation and ET_0 is shown in Table 2.

Reference crop evapotranspiration

Evapotranspiration ET_0 from the hypothetical reference surface, The equations used by the various methods to estimate *ETo*, are summarized in Table 1, And the data requirements are given in Table 2. The psychometric terms (e_a, e_s, Δ, γ) *are* calculated from temperature and humidity records and the radiation terms are calculated using sunshine hours data. To be consistent, all the variables in Table 2 are computed using the equations and procedures recommended in the FAO- 1992 report.

Processing of Rainfall Data

The rainfall contributes to a greater or lesser extent in satisfying CWR, depending on the location. During the rainy season in tropical and some semi-tropical regions, a great part of the crop's water needs are covered by rainfall, while during the dry season, the major supply of water should come from irrigation. How much water is coming from rainfall and how much water should be covered by irrigation is, unfortunately, difficult to predict as rainfall varies greatly from season to season. Mathematically determined average for a series of rainfall records, most commonly available.

Effective rainfall

Defined as that part of the rainfall which is effectively used by the crop after rainfall losses due to surface run off and deep percolation have been accounted for. The effective rainfall is the rainfall ultimately used to determine the crop irrigation requirements. To account for the losses due to runoff or percolation, a choice can be made of one of the four methods given in CROPWAT 8.0 (Fixed percentage, Dependable rain, Empirical formula, USDA Soil Conservation Service).

In general, the efficiency of rainfall will decrease with increasing rainfall. For most rainfall values below 100 mm/month, the efficiency will be approximately 80%. Unless more detailed information is available for local conditions, it is suggested to select the Option “Fixed percentage” and give 80% as requested value. In the water balance calculations included in the irrigation scheduling part of CROPWAT, a possibility exists to evaluate actual Efficiency values for different crops and soil conditions.

Results and Discussion

Monthly weather data and Evapotranspiration are shown in Table 2 in year 2014 for example. And also we show rainfall and effective rainfall in the same year reference crop Evapotranspiration ET_0 and monthly effective rainfall calculated using CROPWAT model. The ET_0 was low in December (63.34 mm/month), increased during the Jan-May, reached maximum value of 170.70 mm/month at May and declined during June-December months. The difference in ET_0 is attributed to combined effects of temperature, sunshine hours, radiation, wind speed and humidity. The increased in ET_0 during the Jan-May can be explained by change in temperature because in this period we obtained the highest temperature. The reduction in ET_0 in the late months because temperature was low. Figure 2: Shows Evapotranspiration due to minimum and maximum temperature the value of ET_0 was so high especially between Jan-May.

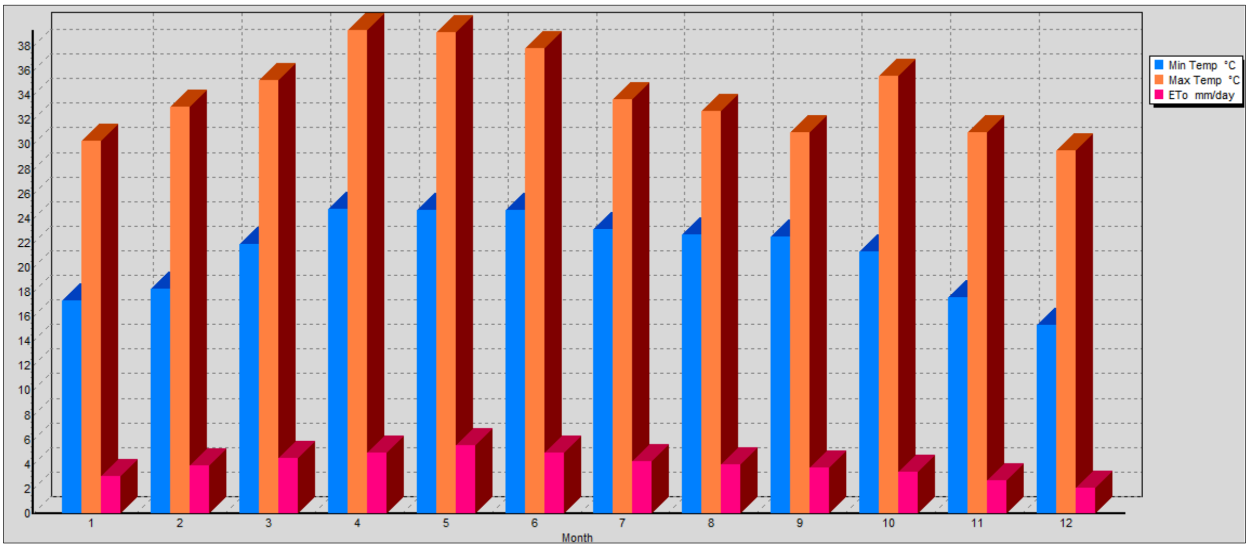


Fig 1: Average monthly Min and Max Temperature and ET_0.

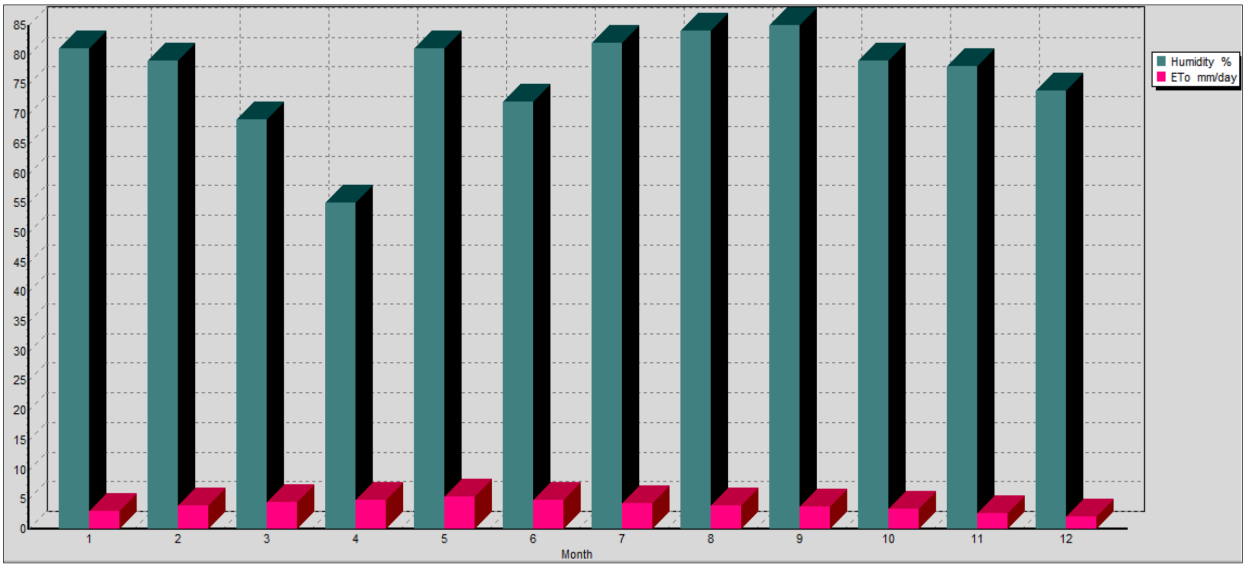


Fig 2: Average monthly Humidity and ET_0.

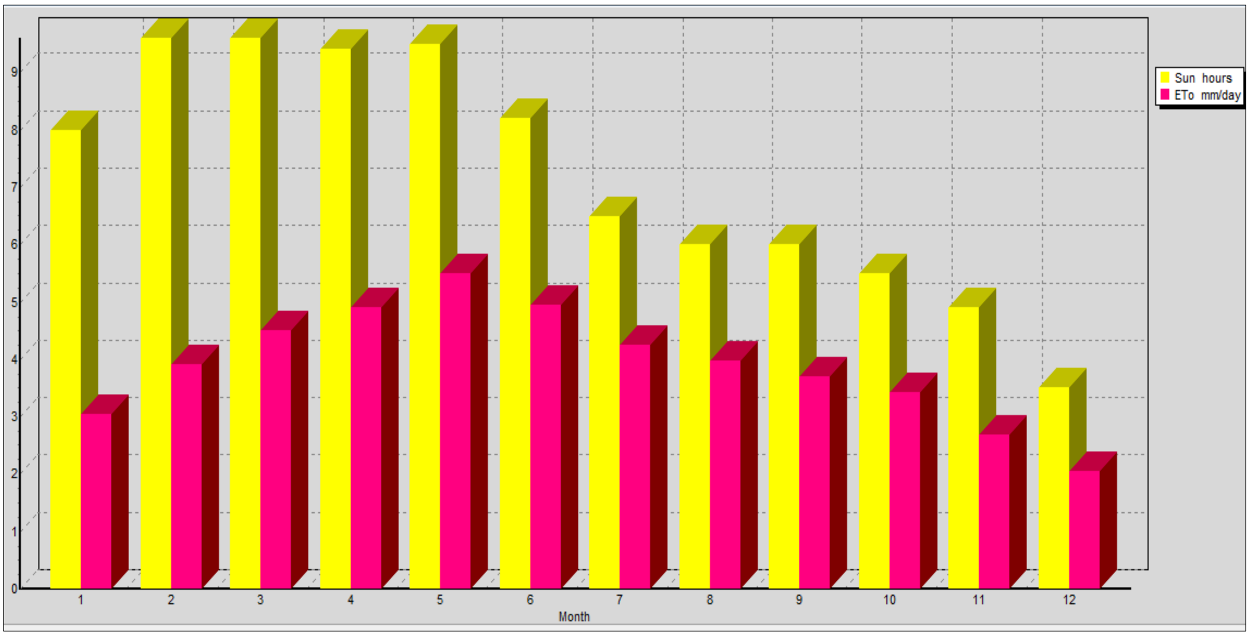


Fig 3: Monthly Sunshine hours and ET_0

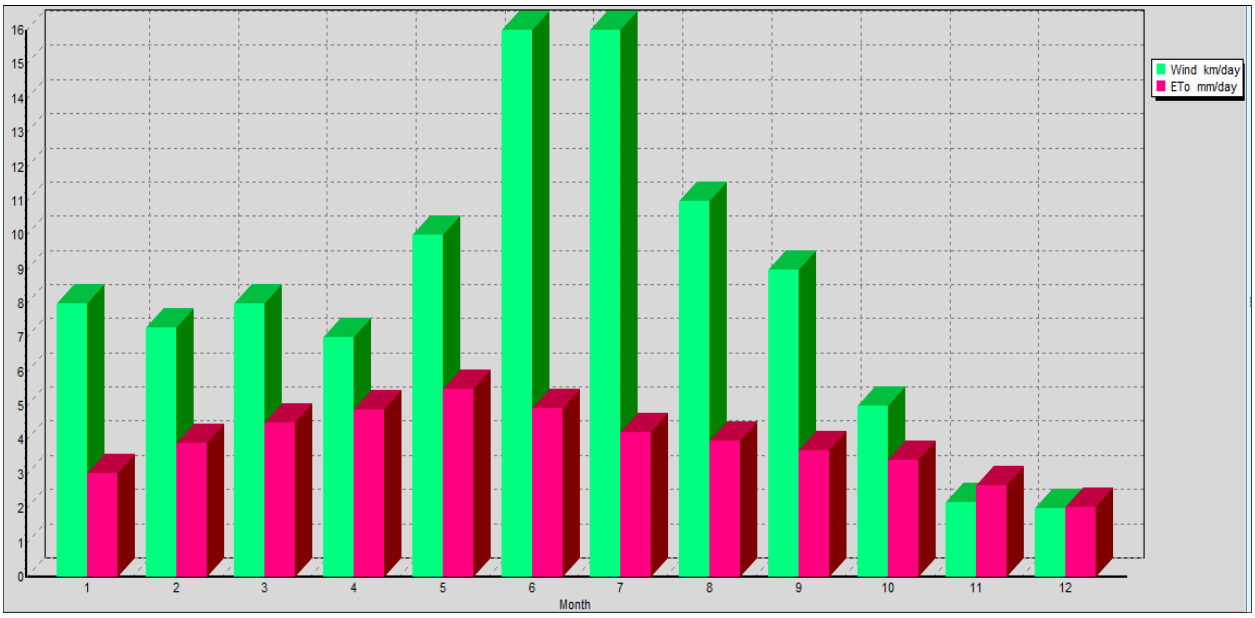


Fig 4: Monthly Wind speed and ET_0.

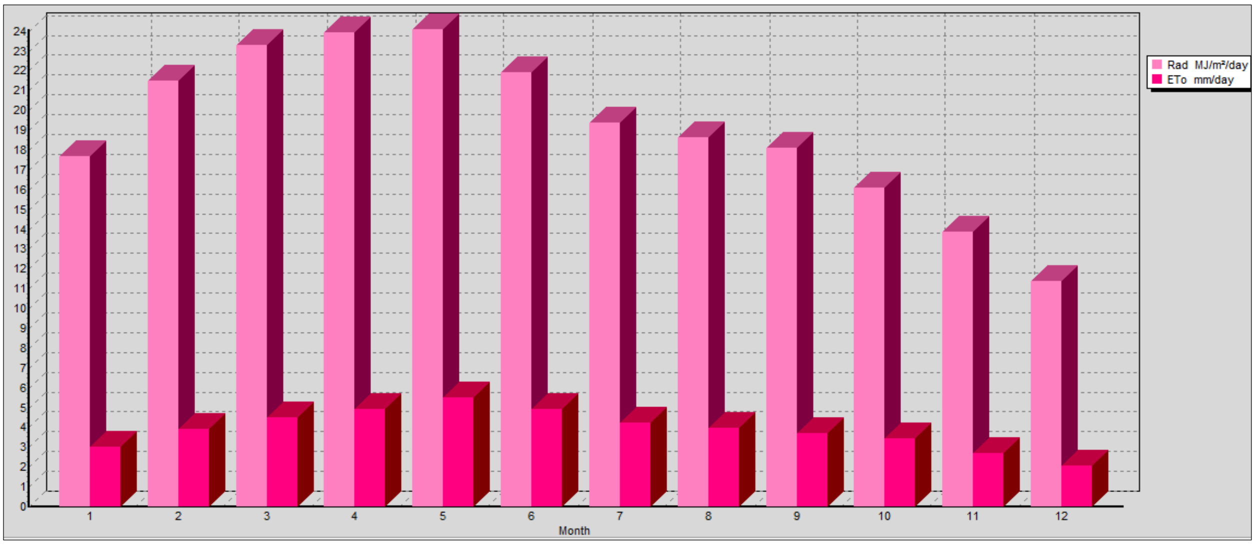


Fig 5: Monthly Radiations and ET_0

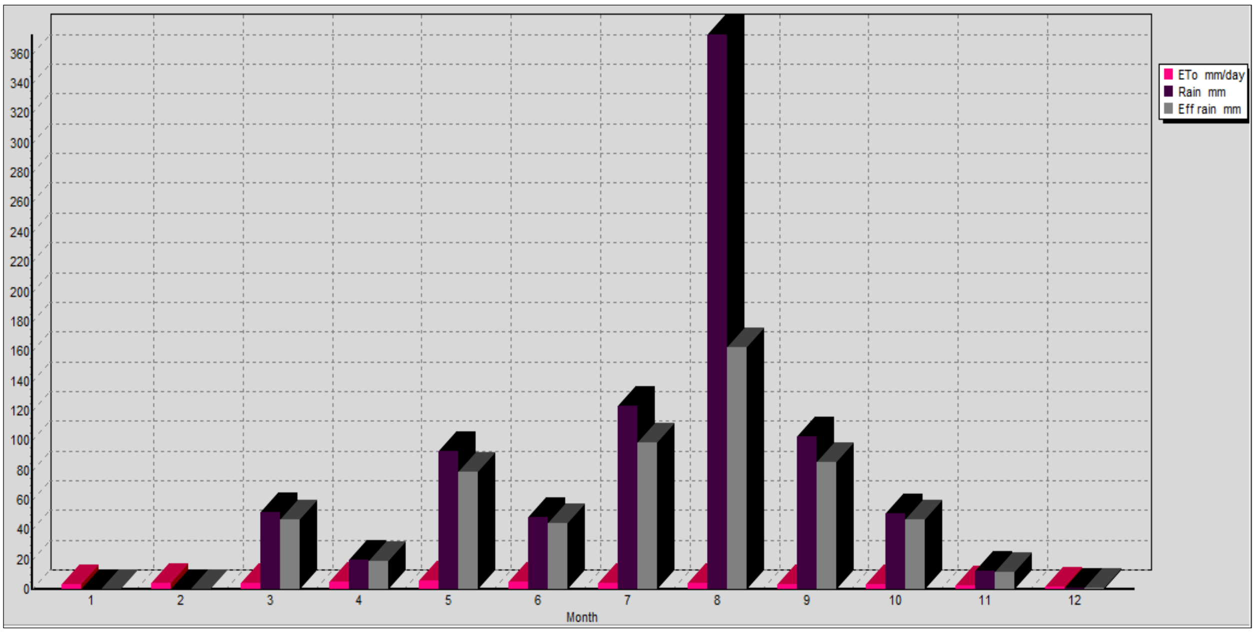


Fig 6: Monthly Rainfalls and Effective Rainfall and ET_0

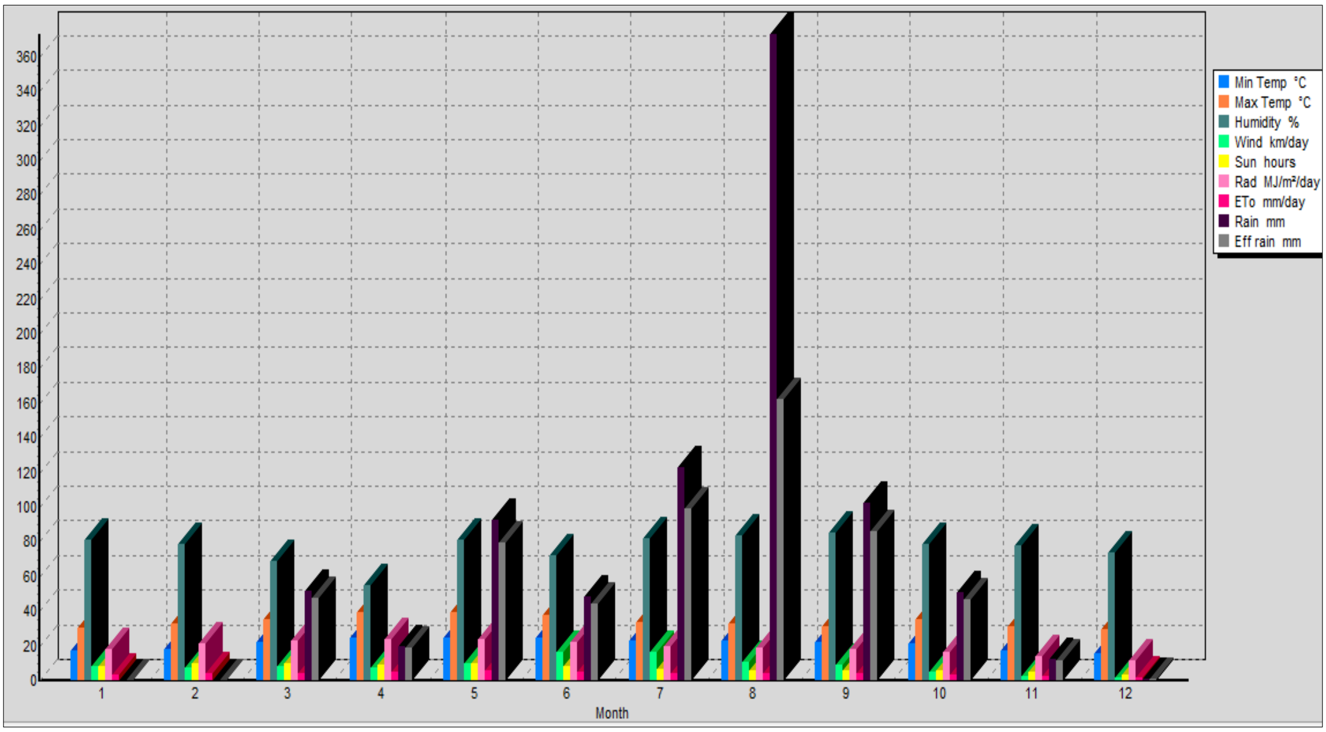


Fig 7: All climatic parameter and ET_0

Figure 1: shows the monthly Humidity and ET_0. As can be seen from the fig, the study area lies in semi arid regions, hence considering the relationship of ET_0 to semi arid climatic region; ET_0 is found in the study to be low due to high humidity in the study area as shown in the plot.

Figure 2: shows the relationship between sunshine and ET_0. From the graph, we noticed the strong relations between sunshine and Evapotranspiration. This is evident that when sunshine hours increase, ET_0 also increases. There is a direct relationship between these two parameters.

Figure 3: shows the relationship of Evapotranspiration with wind speed. The plot indicates that wind speed has no effect on ET_0. Despite changes in wind speed, ET_0 remains constant in the studying findings.

Figure 5: Shows relationship between monthly Radiation and ET_0. It can be observe that, there are fluctuations between the radiation and ET_0. As long as radiation increases, ET_0 also makes a slight increase.

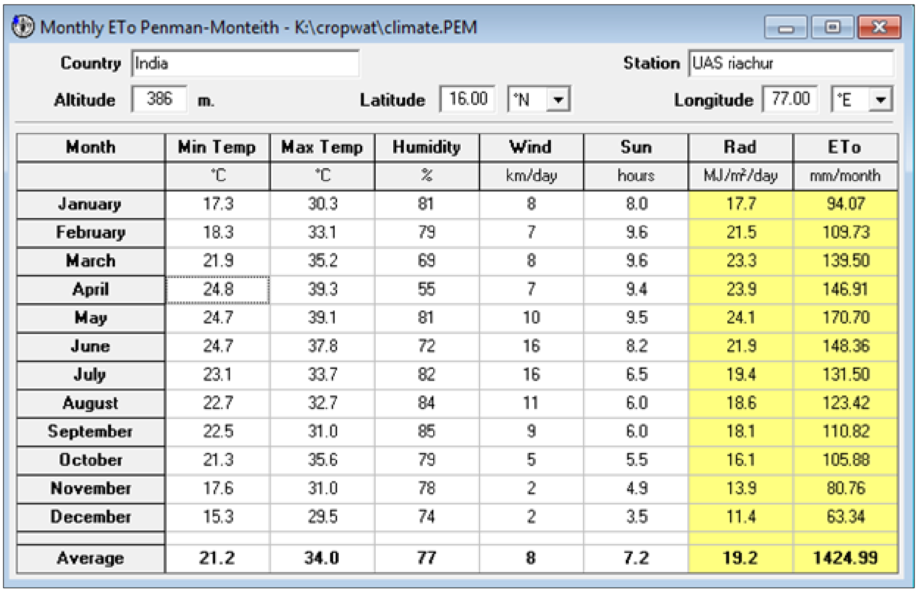
Figure 6: Monthly Rainfall and effective rainfall and ET_0, not all rain which falls is used by the crop. The intensity of rain may be such that part of the rainfall is lost due to surface runoff or due to deep percolation below the root zone.

Figure 7: All climate parameter and ET_0.

Table 1: ETo Methods Advantages and Disadvantages

Method	Equation	Advantage	Disadvantage
Blaney-criddle	ETo=c[p(0.46T+8)] T:mean daily Temp C: factor coefficient depending on minimum relative Humidity. P:mean daily % of annual Day time hours	Simple to use. It can be use when Minimal climatic data is available.	The results can be unreliable for following condition: Equatorial regions, small islands, high altitudes. Its validity is limited to areas where Temp is good indicator of general weather conditions. Should only used to estimate ETo for periods at least one month.
Radiation method	ETo=c(W Rs) Rs: radiation in mm/day W: weighting factor depend on Temp, altitude. C:coefficient depend on humidity and wind	Its gives more reliable result. For equatorial zones, small islands or high altitude than B.C methods. It is relatively simple to use.	The coefficient c needs accurate to produce reasonable results. It's used to calculate ETo for periods at least one month. Its tends to underestimate evapotranspiration in arid climates.
Pan-evaporation	ETo=Kp Epan Kp:pan coefficient Epan: pan evaporation in mm/day	Can be used to predict values of ETo for periods of ten days or longer. Evaporation pan are cheap and simple to set up.	The accuracy is dependent upon the type and location of the pan, color and material of pan effect the evaporation rate. Value of Epan is not const with time.
Penman–Montieth method	ETo= $\frac{0.408\Delta(Rn-G)+\gamma\frac{900}{T+273}u2(es-ea)}{\Delta+\gamma(1+.34u2)}$	The FAO recommend it as sole method to estimate ETo. Climatic data and tool are available from FAO. It can be used to estimate ETo on a daily basis.	Its requires a considerable amount of climate data that may not be readily available however mean monthly climate data is available digitally for 3250 climate station.

Table 2: Printouts – Climate/ETo Data



Country India

Station UAS riachur

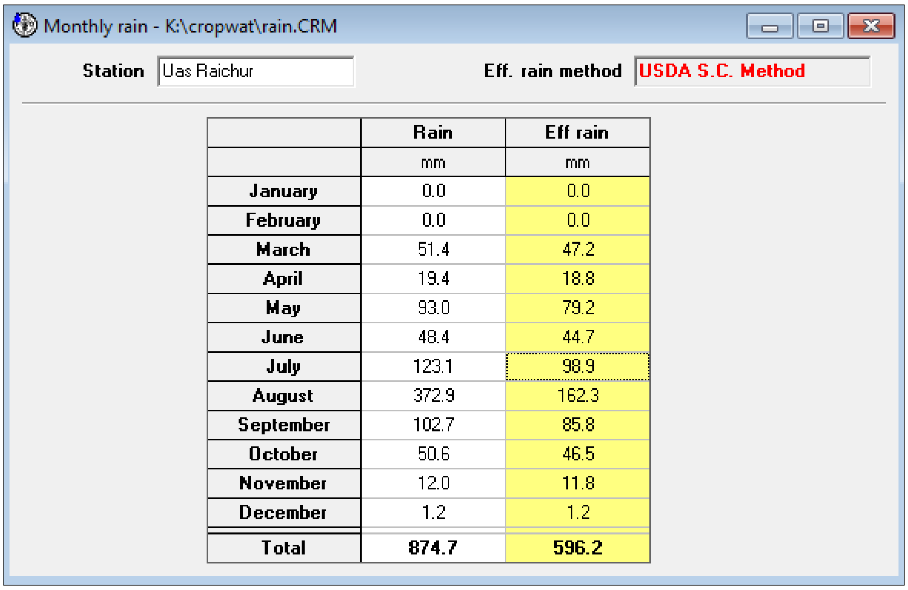
Altitude 386 m.

Latitude 16.00 °N

Longitude 77.00 °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/month
January	17.3	30.3	81	8	8.0	17.7	94.07
February	18.3	33.1	79	7	9.6	21.5	109.73
March	21.9	35.2	69	8	9.6	23.3	139.50
April	24.8	39.3	55	7	9.4	23.9	146.91
May	24.7	39.1	81	10	9.5	24.1	170.70
June	24.7	37.8	72	16	8.2	21.9	148.36
July	23.1	33.7	82	16	6.5	19.4	131.50
August	22.7	32.7	84	11	6.0	18.6	123.42
September	22.5	31.0	85	9	6.0	18.1	110.82
October	21.3	35.6	79	5	5.5	16.1	105.88
November	17.6	31.0	78	2	4.9	13.9	80.76
December	15.3	29.5	74	2	3.5	11.4	63.34
Average	**21.2**	**34.0**	**77**	**8**	**7.2**	**19.2**	**1424.99**

Table 3: Shows a printout of the rainfall data file



Station Uas Raichur

Eff. rain method USDA S.C. Method

	Rain	Eff rain
	mm	mm
January	0.0	0.0
February	0.0	0.0
March	51.4	47.2
April	19.4	18.8
May	93.0	79.2
June	48.4	44.7
July	123.1	98.9
August	372.9	162.3
September	102.7	85.8
October	50.6	46.5
November	12.0	11.8
December	1.2	1.2
Total	**874.7**	**596.2**

Conclusion

The FAO-Penman-Montieth equation is recommended as the standard method for estimating reference and crop Evapotranspiration. The new method has been proved to have a global validity as a standardized reference for grass Evapotranspiration and has found recognition both by the International Commission for Irrigation and Drainage and by the World Meteorological Organization. Procedures have been established to estimate missing climatic data which allow the FAO Penman-Montieth method to be used under all conditions. This eliminates the use of any other method and will increase the transparency and consistency of reference and crop water requirement studies.

Main conclusion from this study was diagrams of all parameter effects in ET_0 estimation specially temperature, sunshine hours and radiation. This means penman–montieth is the best method to estimate ET_0 because its take all parameter in calculation.

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