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ESTIMATION OF EVAPO-TRANSPIRATION BY DIFFERNET METHODS (COMPARISION) - A CASE STUDY

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ABSTRACT

Limited information exists on reliable estimates of evapo-transpiration, which can be used for developing scientific irrigation schedules and to achieve higher water use efficiency in the semi-arid environments. Reliable estimates of reference crop Evapo-transpiration (ETo) are required for efficient irrigation management. The objective of the study is to estimate the reference crop Evapo transpiration (ETo) with various methods like Penman Motieth FAO-56, Branley Criddle, Christiansen. Gulbarga Taluka is a part of the Gulbarga District with a geographical area of 1,73,453 Hectares lies between 16° 11'-17° 45' N, 76° 03'-77° 30' E. large proportion of the land area is deep black cotton soil. The annual ETo of Gulbarga taluka is estimated as 1631mm. April, May are the months with highest evaporative demand and December and January are the months with lowest ETo values. The total annual precipitation of the study area is 776mm. maximum rainfall occurrence is seen in the month of July and August. Rain fed agriculture is rather difficult in the study area.

***Keywords*: FAO-56, Evapo-transpiration (ETo), Branley Criddle, Christiansen , Variation, water balance, semi arid environments, water use efficiency, evaporative demand**

I. INTRODUCTION

Evapo-transpiration is the combination of soil evaporation and crop transpiration. Weather parameters, crop characteristics, management and environmental aspects affect Evapo-transpiration. The Evapo-transpiration rate from a reference surface is called the reference Evapo-transpiration and is denoted as ETo. A large uniform grass (or alfalfa) field is considered worldwide as the reference surface. The reference grass crop completely covers the soil, is kept short, well watered and is actively growing under optimal agronomic conditions.

The concept of the reference evapo-transpiration was introduced to study the evaporative demand of the atmosphere independently of crop type, crop development and management practices. As water is abundantly available at the reference evapo-transpiring surface, soil factors do not affect ETo.

Reference crop evapotranspiration is an evapotranspiration calculated on reference crop which is not short of water and denoted by ET Reference surface is a hypothetical grass having specific characteristics. Evapotranspiration of reference crop is calculated and then the value is related to other surfaces. So there is no

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need to calculate separate evapotranspiration for each crop and stage of growth. It is independent of crop type crop development stage and management practices.

II. DETAILS OF THE STUDY AREA

Gulbarga Taluk comes under Gulbarga district which is located in the northern part of Karnataka state. It falls in the northern maidan region, between 16° 11' - 17° 45' North Latitude and 76° 03' - 77° 30' East Longitude, and lies between two major rivers namely the Krishna and the Bhima. It is bounded on the north by Bidar district, on the west by Bijapur District, on the south by Raichur District and Andhra Pradesh in the east. It has an area of 16,741 square kilometers. The land under cultivation is almost 76% of the total area. The district experiences the temperature variation between 230 °C and 400 °C and receives and average annual rainfall of 776 mm and is not uniformly distributed all over.

Study area Gulbarga Taluk has geographical area of 1734.53 Sq Kms.

III. MATERIALS AND METHODOLOGY

FAO 56 Penman-Monteith method is recommended as the sole ETo method for determining reference evapotranspiration, also we have other methods for computing the same, due to variation in results methods are not preferred extensively. The first method, its derivation, the required meteorological data and the corresponding definition of the reference surface are described along with that it discusses the source, measurement and computation of all data required for the calculation of the reference evapotranspiration by means of the FAO Penman-Monteith method.

i. Penman-Monteith Equation

The panel of experts recommended the adoption of the Penman-Monteith combination method as a new standard for reference evapotranspiration and advised on procedures for calculation of the various parameters. By defining the reference crop as a hypothetical crop with an assumed height of 0.12 m having a surface resistance of 70 s m-1 and an albedo of 0.23, closely resembling the evaporation of an extension surface of green grass of uniform height, actively growing and adequately watered, the FAO Penman-Monteith method was developed.

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

Source: FAO Irrigation and Drainage Paper No. 56

Where,

ETo - Reference evapotranspiration [mm day-1],

Rn - Net radiation at the crop surface [MJ m-2 day-1],

G-soil heat flux density [MJ m-2 day-1],

T-Mean daily air temperature at 2 m height [°C],

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u2- Wind speed at 2 m height [m s-1],

es - Saturation vapour pressure [kPa],

ea - actual vapour pressure [kPa],

(es-ea) - Saturation vapour pressure deficit [kPa],

Δ - Slope vapour pressure curve [kPa °C-1],

Γ - Psychrometric constant [kPa °C-1]

The equation uses standard climatological records of solar radiation (sunshine), air temperature, humidity and wind speed.

ii. Meteorological Data

The methods for calculating evapotranspiration from meteorological data require various climatological and physical parameters. Some of the data are measured directly in weather stations. Other parameters are related to commonly measured data and can be derived with the help of a direct or empirical relationship.

Following are the meteorological data needed in determining ETo.

a) Solar radiation

b) Air temperature

c) Air humidity

d) Wind speed

e) Atmospheric Parameters

f) Atmospheric pressure (P)

IV. ESTIMATING WEEKLY REFERENCE EVAPOTRANSPIRATION (ETO)

Values of ETo [mm week-1] comparing with three methods as shown in Figure-1 were computed on daily basis using the procedures which were outlined earlier & also by PET-Calculator for other methods. The weekly average value of ETo by (FAO56-PM) for the year 1995-2013 is 30.223 [mm week-1], the maximum value is 49.36 [mm week-1], and the minimum value is 21.03 [mm week-1].

- Graphs shows the variations in climatic parameters required to calculate ETo.

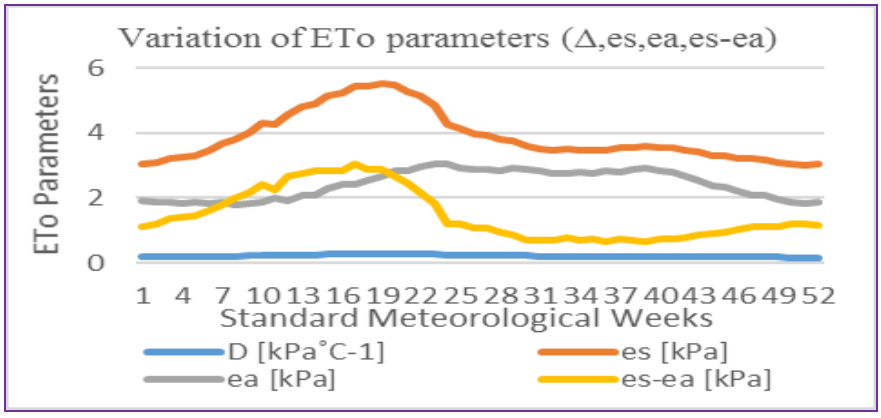

Figure 1: Variation of ETo parameters

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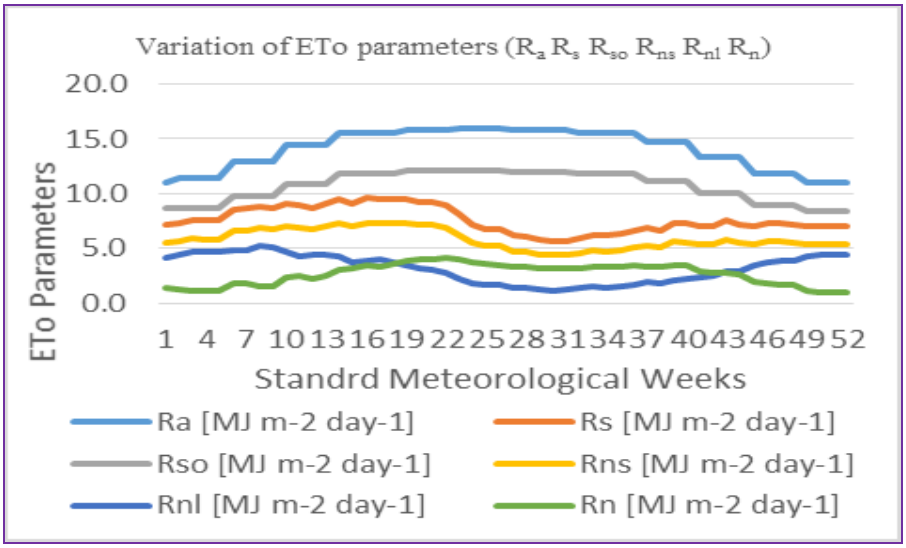

Figure 2: Variation of ETo parameters

V. RESULT & DISCUSSIONS

The climatic parameters of Gulbarga taluka region for nineteen years covering period from January 1995 - December 2013 were used. First of all data for normal condition was selected by applying stringent definitions of adequate soil moisture conditions, crop evapotranspirating at potential rate and completely shading ground as per guidelines mentioned in FAO 56 (Allen et al., 1998). Figure 1 & 2 shows the comparison of different weather parameters at the study area, data labels of average weather parameters have also indicated in this figure. Figure 1 & 2 shows the variability of all the weather parameters which is in the proximity of variability one can expect to find at any study region. Figure 3 shows the variation of ETo for standard meteorological weeks (SMW).

The weekly average value of ETo by (FAO56-PM), Branley Criddle & Christiansen for the year 1995-2013 is 30.223, 31.32423 & 17.74981 [mm week-1], the maximum values are 49.36, 50.5 & 28.46 [mm week-1], and the minimum value is 21.03 [mm week-1].

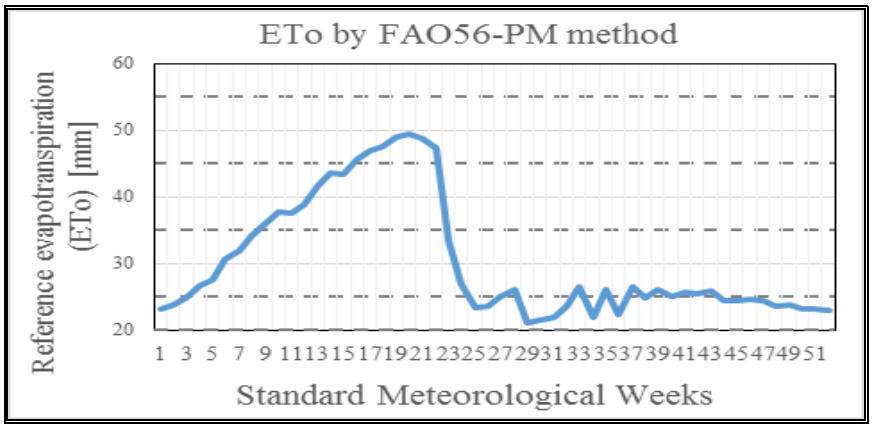

Figure 3: Weekly Variations in ETo

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ETo values calculated by standard method ie; (FAO PM-56) represented in figure 3 indicates that, values are high by 576.76mm in Summer season followed by value of 419.86 mm in southwest monsoon (Kharif Season), in winter season a value of 352.21 mm is observed & during northeast season ETo value is found to be 316.45 mm which is least value when compared with all seasons. From the above figure the values of reference ETo values are accurate due to the input parameters involved in the calculations and recommended method for the same.

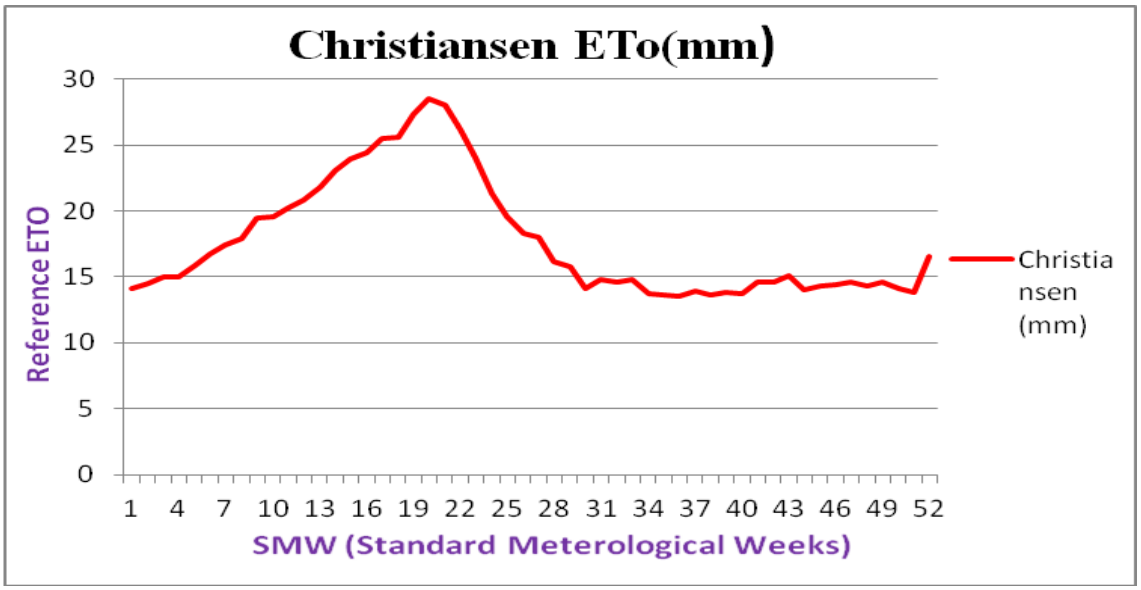

Figure 4: Weekly Variations in ETo by Christiansen Method

ETo values calculated by Christiansen method represented in figure 4 indicates that, values are high by 334.36 mm in Summer season followed by value of 273.51 mm in southwest monsoon (Kharif Season), in winter season a value of 126.57 mm is observed. ETo values with this method are too low when compared with other two methods.

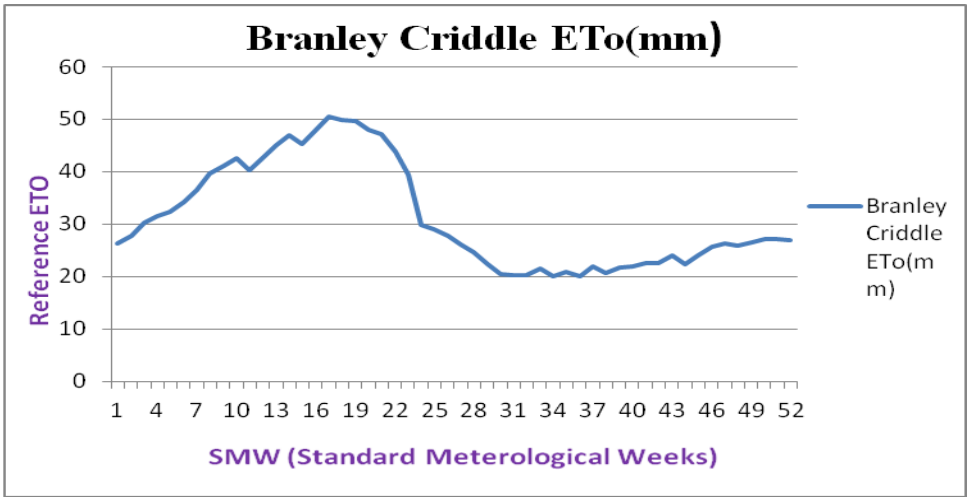

Figure 5: Weekly Variations in ETo by Branley Criddle Method

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ETo values calculated by Branley Criddle method represented in figure 5 indicates that, values are high by 640.78 mm in Summer season followed by value of 406.96 mm in southwest monsoon (Kharif Season), in winter season a value of 258.56 mm is observed. All seasonal values calculated with this method gave slightly higher values when compared with FAO PM-56 method.

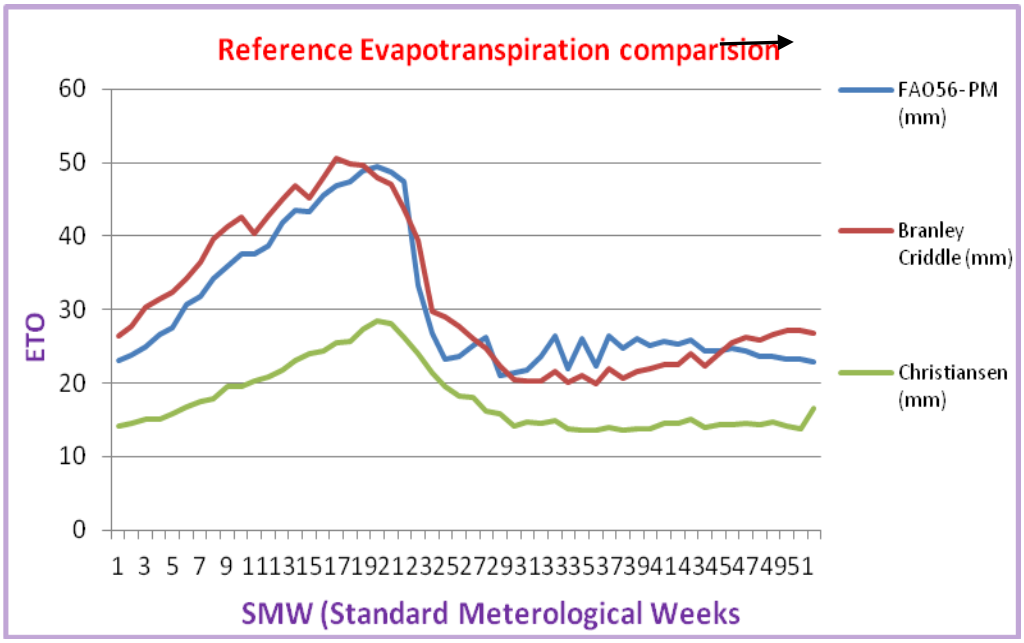

Figure 4: Variations in ETo comparision

From figure 4 it is clear that Accuracy in ETo values are variating in different seasons, in winter season we can say that ETo value are ranging from 22 to 34. When we see in figure 5 summer season from 9th to 22nd week slightly increased value in ETo is seen. In kharif season shown in figure 6, trend is slightly different when compared to other seasons, from 23rd week ETo values shows linearly falling trend with higher value of 53.7 mm to 26 mm, whereas in northeast season figure 7 only first two weeks ETo value is higher. As we can see from Figure 4 there is variation in the values of ETo, parameters used for standard method which is recommended by FAO worldwide gives good results whereas Branely Criddle method slightly follows first method and Christiansen method lack behind.

Overall values in this study shows that the max value is found to be in summer season and lower values in northeast season with standard method (FAO PM-56).

VI. FUTURE SCOPE

This study will be beneficial for all farmers as well as people coming under this command area. During non-availability of meteorological data, if characteristics of one command area (with calculated ETo) match with other, then we can apply same ETo values to that area where data is missing. After finding out the crop water requirements, water will be applied as per the requirement of that crop and hence water balance system can be developed. Irrigation requirements are calculated with the help of crop water requirement of each crop. That is nothing but the water required for that crop to fulfill their need.

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VII. CONCLUSIONS

1. Study reveals that estimation of ETo is very important for proper planning and managing in fields, in study area major changes is due to drought condition.
2. Standard Method (FAO PM-56) is recommended for the estimation of ETo for a better yield.
3. The estimated ETo methodology can be integrated into daily rainfall events to arrive actual shortage or excess water on any given day and this detailed study will help to water conservation planning for Study area and for sustainable water management planning and development.
4. From studies we also came to know that ETo is more in summer with value 576.6 mm.
5. For above condition proper measures to be taken to get a crop yield better.

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