Comparison of Different Methods for Estimating Reference Evapotranspiration in Semi-arid region
- A Review

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Abstract – Evapotranspiration is a total loss of water from land surface and plant surface. Therefore its precise estimation required for many hydrological studies. However, Reference evapotranspiration is adopted by ASCE as a standard representation of evapotranspiration. Many Methods are available for estimating reference evapotranspiration. In this paper, different Temperature and Radiation based methods are studied and determined the most appropriate method to estimate reference evapotranspiration in semi-arid region. The study shown that Hargreaves method is most suitable for Semi-arid region of warm country.

Keywords – Reference Evapotranspiration, FAO-56 Panman-Mointh, Radiation based method, Temperature based method, semi-arid condition
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I.   INTRODUCTION

Evapotranspiration is a most important function of hydrological meteorological studies. Its accurate estimation is required for water resources planning, irrigation planning and management. For Estimating Evapotranspiration first calculate the reference evapotranspiration (ET_o) and then apply to various crop co-efficient. Reference Evapotranspiration is defined in Allen et al. (1998) as "The rate of evapotranspiration from hypothetical crop with an assumed crop height canopy resistance and albedo which would closely resemble evapotranspiration from an extensive surface of green grass cover of uniform height, actively growing, completely shading the ground and not short of water". Evapotranspiration can be measured by lysimeter. This instrument is very costly and time consuming and not feasible for different plants vegetated surface. Therefore in past fifty years much research has been done to estimate ET_o mathematically by various method such as temperature based and radiation based method based on variable climatic parameters.In this study compare the different method such as Hargreaves (Temperature based), FAO-24 Radiation, Priestley-Taylor, Makkink and Turc (Radiation based) with FAO-56 Panman – mointh equations and gives the idea about which method is best fit for FAO-56 Panman – mointh method for the semi-arid region of the Saurashtra Gujarat india.

II.   DESCRIPTION OF METHOD

The ET estimation are generally grouped into temperature, radiation and combination based. which describe below.
2.1) Temperature based method :

1) Hargreves and samani(1985):
Hargreves and samani proposed an equation for estimating ETo.
$$ETo = a(T_{max} - T_{min})(T_m + b) R_a$$
Where R_a is total Extra-terrestrial solar radiation (MJKg^{-1}), T_{max} & T_{min} is minimum & maximum air temperature (^{o}C), a & b are calibration constants.

2.2) Radiation based method :

Various radiation based method such as Turc, Makkink, Pristely-Taylor, FAO-24 radiation etc. are given below.
1) Turc(1961):
Turc Proposed the following equations for two humidity conditions.
$$ETo = a (T_m (R_{s+} 50)/T_m + 15) \text{ if RH} >50\%$$
$$ETo = a(T_m (R_{s+} 50)/T_m + 15)(1+(50\text{-}RH/70)) \text{ if RH is}<50\%$$
Where R_s is solar radiation (MJKg^{-1}), RH is relative humidity in % and T_m is mean temperature in ^{o}C.

2) Makkink (1957) :

Makkink gives the following equation.

$$ETo = a(\Delta/(\Delta+\gamma))((R_s\text{-}G)/2.45)\text{-}b$$

Where a,b and c are calibration constants. Δ is slope vapour pressure curve(KPa $^oC^{-1}$). γ is psychometric constants(KPa $^oC^{-1}$).

3) Priestely and Taylor (1972):

Priestely and taylor gives the following equation based on radiation method such as

$$ETo = a(\Delta/(\Delta+\gamma))((R_n\text{-}G)/\lambda)$$

Where λ is the latent heat of vapourization(MJ Kg^{-1}). G is the soil flux density (MJ m^{-2} day^{-1}).

4) FAO-24 Radiation :

Doorenbos and Pruitt (1977) presented a radiation method for
estimating ET using the solar radiation. The equation is given as:

$$ETo = a+b(\Delta/(\Delta+\gamma))R_s\,(1/\lambda)$$

Δ is slope vapour pressure curve(KPa $^oC^{-1}$). γ is psychometric constants(KPa $^oC^{-1}$). Where λ is the latent heat of vapourization(MJ Kg^{-1}).

2.3) Combination method :

The daily ETo is calculated by FAO-56 Panman – mointh equation

1) FAO-56 Panman – mointh(1963) :

Allen et al. (1996, 1998) presented the following form of the Penman-Monteith model for estimation of ETo in mm/day is given as a:

$$ETo = (0.408\,\Delta(\,R_n\text{-}G) + \gamma\,(900/Tm +273)u_2(e_s\text{-}e_a))/\,\Delta + \gamma(1+0.34\,u_2)$$

Where R_n is the net solar radiation (MJ m^{-2} day^{-1}), G is the soil flux density (MJ m^{-2} day^{-1}),u_2 is the wind speed (m s^{-1})at 2m height, Tm is the main daily air temperature at 2m height, Δ is slope vapour pressure curve(KPa $^oC^{-1}$). γ is psychometric constants(KPa $^oC^{-1}$), e_s is the saturation vapour pressure(KPa), e_a is the actual vapour research on pressure (KPa).

III. LITERATURE REVIEW

Ruiz-Canales et al., (2015) examined different methods to determine ETo in semiarid region of SE Spain and concluded that Hargreaves equation can provide relatively accurate estimation of daily ET_o under the semiarid conditions of the studied zone.

Yu-Min Wang et al.(2009) shown that in semi-arid region, temperature based method provides relatively reliable results in Ngabu and Chileka of Malawi.

Omotayo B. Adeboye et al. (2014) compared the different methods of estimating ETo and suggested that in semi-arid region of Nigeria, the temperature based method found suitable.

Edebeatu, Chinedu C. and Okujagu, Charity U.(2015) examined that A new model has been developed to estimate reference evapotranspiration in a semi – arid region of Nigeria is a temperature – based model that requires only maximum and minimum air temperature that is readily available and that can also easily be measured as a meteorological parameter.

IV. CONCLUSION

In this paper, different methods to determine ETo are studied. The appropriate methods recently used by researchers also studied. The recent scenario, show that temperature and radiation based methods such as Hargreaves (Temperature based), FAO-24 Radiation, Priestley-Taylor, Makkink and Turc (Radiation based) with FAO-56 Panman – mointh equations for estimate reference evapotranspiration usually found most satisfactorily. However, recent study show that temperature based method is best suited for semi-arid region.

V.REFERENCES

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