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Mathematical Model for Evaluating Evapotranspiration for Several Meteorological Zones in Tamilnadu.

S Priyadharshini[1]*, R Aroul Canassane[2], and MM Vijiyalakshmi[3]

[1]Department Of Computer Science and Engineering, Jeppiaar Engineering College, Chennai, Tamil Nadu, India.
[2]Department Of Computer Science and Engineering, Sathyabama University, Chennai, Tamil Nadu, India.
[3]Department Of Civil Engineering, Sathyabama University, Chennai, Tamil Nadu, India.

ABSTRACT

Tamilnadu suffers an inadequate rainfall in recent years; in order to yield more we need proper irrigation management which results in efficient use of every drop of water. In irrigation water management the accurate estimation of evaluating evapotranspiration is a necessary step for calculating the water loss. Evapotranspiration (ET), process is a simultaneous occurrence of evaporation and transpiration in crop field. The amount of data for evaluating the result is not available all time therefore the value of parameter required for particular method at any time is sufficient to evaluate ET. FAO-56 Penman Monteith method draws attention in all kinds climatic zone to evaluate reference ET, which is considered as a standard method by FAO. In this paper, four different methods such as Penman Monteith, Penman, Priestley Taylor, Blaney- Criddle and twelve meteorological stations from different zones in Tamilnadu is taken in account to evaluate evapotranspiration for three major agro season like Kharif, Rabi, and Summer whereas to provide optimized result.

Keywords: Irrigation management, evapotranspiration, FAO.

Corresponding author

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INTRODUCTION

In recent years farmer related issue is becoming a threat to Tamilnadu, where farmers face problem related to improper irrigation. The reason behind it is Tamilnadu lacks in maintaining reservoirs, lakes and irrigation well for cultivation. To predict water loss we have to take serious measure to avoid crop failure. Crop failure which doesn't meet the estimated yield and it brings huge loss to the investment spent by the farmer. Incorporating the technology into irrigation field will bring estimated crop production and high profit to the farmers. Encouraging organic farming will form healthy food environments which bring high profit in the market than the one with hybrid seeds.

In general 90 percent of water loss is due external heat energy that leads to evaporation of water in crop field, transpiration happens from capillary fringe of plant itself which is of only 10 percent. The related climatic factor that affects evapotranspiration is wind speed and it varies spatially and temporally. The wind speed increases the temperature level, produces heat energy and removes the moisture content from the plant surface.

CURRENT SCOPE OF AGRICULTURE

Human without food is like a nightmare, so in order to fulfil the food demand for growing population is a major task. Even though we provide huge productivity with our modern technology somewhere the other crop failure happens in huge, the reason behind it is adapting cross pollination seeds to speed up the cultivation period, using harmful pesticides which results in drying of crops and destroys the nutritive value of the soil and the major factor is seasonal change too. Following our traditional process will bring our soil texture, its nutritive value and high crop yield and healthy food for our future generation. Agriculture provides an excellent platform in current environment where experts do precise farming in successive rate in case of both crop yield and profit.

STUDY AREA

Twelve meteorological stations such as dusiayyangarkulam station from Thiruvanamalai, karunkuzhi station from kanchipuram, golapally station from Vellore, kiladayalam station from villupuram, Kilnachipattu station from Thiruvanamalai, Krishnagiri Reservoir station from Krishnagiri, Melumalai station from krishnagiri, palur station from cuddalore, Thirukoilur FCS station from villupuram,Vaniyar reservoir station from dharmapuri, Thiruthani (EWS) station from thiruvallur, cuddalore station from Chidambaram. Here different meteorological stations from Tamilnadu are taken account for estimating water loss by various principles methods of evapotranspiration. From ancient time Tamilnadu is a major cultivator of paddy, rice, sugarcane, millets and pepper. The study made here to cultivate crops based on availability of water and nature of soil in order to yield more and suggest farmers to do crop rotation which retain our soil texture and crops can be cultivated on basis of season like kharif, Rabi and summer. Tamilnadu experience the temperature fall and rise from 21 degree Celsius to 45 degree Celsius, and with adequate to inadequate rainfall.

LITERATURE REVIEW

M.D.Mata, K.A.Salunke, P.PBhangale (2014) [1], developed a software to calculate the evapotranspiration, which makes tedious calculation simple and efficient. In this paper author concentrated on five principle methods of evapotranspiration, the following evapotranspiration methods are Lysimeter, Hargreaves class 'A' pan, Field plot method, Blaney-Criddle and Penman formulae. The advantage of developed software is much easier, does tedious calculation in ease, comparison can be done by evaluating different methods, easy installation and planned irrigation.

Ankit K.Kulkarni, Ravichandra Masuti, V.S.Limaye (2015) [2], study defines that FAO 56 Penman Monteith is the based method suggested by Food and Agricultural Organization in recent time, which is suitable for all climatic condition. Because FAO 56 deals with large amount of meteorological data, but it is not available at all climatic stations. Sohere seven different methods are taken in account to find out the mere best method nearer to FAO 56 PM method. When compared to physical methods like Lysimeter and Hargreaves class 'A' pan method deals with less amount of data, but FAO 56 PM method gives us accurate and optimal result.

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Bhaskar R.Nikam, Pradeep Kumar, VaibhavGarget.Al (2013) [3], this paper deals with important aspect of evapotranspiration as we know FAO 56 PM method is the standard method calculating RET, whereas the old methods require less amount data and gives results close to FAO 56 PM method. To find the best alternate methods author used two temperature based and two radiation based approaches are used to calculate RET is Hargreaves, Thornthwaite, Priestley-Taylor and Turc and finally the result is compared with FAO 56 PM method. The data taken evaluate RET is from Pantnagar in Uttarakhand. In regression analysis, Hargreaves method gives more accurate when compared to FAO 56 PM method.

HariDattaPaudel and AshishPandey (2013) [4], study defines in 50 years of research, N number of methods are used to evaluate RET. The methods can be temperature based approach, radiation based approach, pan evaporation based approach and combination based equations are used and compared with standard FAO 56 PM method. For this study Sikta irrigation area in western Nepal is taken, here five principle methods are used such as FAO Penman Monteith, Modified Penman, Hargreaves, Class A Pan Evaporation, FAO paper-56 Pan Evaporation and Orang coefficient. Paper concluded that the Orang coefficient gives the mere best result when compared to our standard FAO 56 PM method.

METHODOLOGY

Methodology consists of four principle methods which are taken in concentration to evaluate evapotranspiration. Manual process is not possible literally so we use MATLAB software to code and calculate the result which is as easy as using calculator, the user may just input values for required field and it provides an output result of ET. The comparison is made between with these four principle method and achieve the exact result for that particular region. Then linear regression and root mean square (rmse) gives more accurate and optimized result.

FAO PENMAN-MONTEITH METHOD:

The equation for Penman-Monteith is referred from FAO is

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

PENMAN METHOD:

The equation for Penman method is referred from FAO is

$$E_{\text{mass}} = \frac{mR_n + \rho_a c_p (\delta e) g_a}{\lambda_v (m + \gamma)}$$ ---------- (2)

BLANEY-CRIDDLE METHOD:

The equation for Blaney-Criddle method is referred from FAO is

***ETo* = *p* (0.46·*Tmean* + 8) ---------**	(3)

PRIESTLEY AND TAYLOR:

The equation for Priestley and Taylor method is referred from FAO is

$$ET_O = \frac{I}{\lambda} \cdot \frac{s \cdot (R_n - G)}{s + \gamma} \cdot \alpha$$ ---------- (4)

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NOTATIONS

ρa = air density in kg m-3,

Cp = specific heat of dry air [~1.013 x 10-3 MJ kg-1 ºC-1]

es = mean saturated vapor pressure in kPa computed as the mean eo at the daily minimum and maximum air temperature in ºC

ra = bulk surface aerodynamic resistance for water vapor in s m-1 ea = mean daily ambient vapor pressure in kPa rs = canopy surface resistance in s m-1

ETo = Reference evapotranspiration (mm/day)

Rn = Net radiation at the crop surface (MJ/m2 per day)

G = Soil heat flux density (MJ/m2 per day)

T = Mean daily air temperature at 2 m height (°C)

u2 = Wind speed at 2 m height (m/sec)

es - ea = Saturation vapour pressure deficit(kPa)

Δ= Slope of saturation vapour pressure curve at temperature T (kPa/°C)

γ= Psychometric constant (kPa/°C)

λ=Latent heat of vaporizations, [MJ/kg] [2.45 MJ/kg],
Rs =Solar radiation, [MJ/m2 d-1]

RESULTS AND DISCUSSION

FAO Penman Monteith is the sole standard method for evaluating evapotranspiration. Therefore here four principle methods are taken into account for finding mere best method. After evaluating the values of ET. RMSE calculation is done to rectify the error which gives us more accurate and optimized result.

	season wise for 12 location for year 2014				
				kharief	
Location	Actual P	Penma	Blaney-(	Priestley-	Penman
Dusi Ayya	2.093	6.135	6.543	10.303	6.600
Gollapally	1.849	6.755	6.063	10.233	6.218
KARUNKU	2.835	5.875	5.933	10.123	6.170
Kiladayala	3.408	6.500	6.195	10.305	6.543
Kilnachipa	2.619	6.498	6.645	10.333	6.783
Krishnagir	3.704	5.953	5.953	9.950	6.015
Cuddalore	3.362	6.763	6.763	10.510	7.248
Melumala	4.050	5.753	5.753	9.965	6.083
Palur	2.996	6.380	6.783	10.695	6.768
Thirukoilu	3.094	5.778	5.938	10.108	6.003
Vaniyar re	3.440	5.838	5.705	9.845	5.838
Thiruthani	2.451	6.495	6.873	10.745	6.495

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Fig 5.1: ET is calculated for 12 locations: For kharif season.

RABI					
Location	Actual	Penmar	Blaney	Priestle	Penman
Dusi Ayya	1.546	5.123	6.350	8.883	5.375
Gollapally	1.698	5.093	6.405	8.880	5.285
KARUNKU	2.569	5.020	6.108	8.723	5.253
Kiladayala	1.629	4.893	5.693	8.550	5.130
Kilnachipa	1.433	5.083	6.005	8.708	5.420
Krishnagir	3.409	4.938	4.938	8.480	5.293
Cuddalore	2.187	5.503	5.503	8.985	5.963
Melumala	2.864	4.828	4.828	8.480	4.940
Palur	2.054	5.165	6.418	8.718	5.430
Thirukoilu	2.172	4.985	6.103	8.725	5.153
Vaniyar re	1.740	4.873	5.745	8.458	4.953
Thiruthani	1.261	5.263	6.718	8.998	5.258

Fig 5.2: ET is calculated for 12 locations: For Rabi season

SUMMER					
Location	Actual P	Penman	Blaney-	Priestley	Penman
Dusi Ayya	2.383	7.753	6.633	12.598	8.198
Gollapally	2.197	7.573	6.333	13.175	7.900
KARUNKU	3.275	7.565	6.328	13.020	7.915
Kiladayala	3.019	7.288	5.808	12.643	7.460
Kilnachipa	2.052	7.925	6.493	13.250	8.603
Krishnagir	4.239	7.618	7.618	12.633	7.825
Cuddalore	3.132	8.258	8.258	13.675	8.955
Melumala	4.420	8.130	8.130	13.685	8.438
Palur	3.169	7.878	6.758	13.385	8.043
Thirukoilu	3.214	7.320	6.010	12.813	7.540
Vaniyar re	3.591	7.575	5.953	12.773	7.573
Thiruthani	2.398	8.183	7.248	13.840	8.183

Fig 5.3: ET is calculated for 12 locations: For Summer season

YEAR	STATION	DISTRICT	RMSE	RMSE	RMSE	RMSE
2014			PM METHOD	BLANEY	PERSTELY	PENMAN
	DUSI AYYANGARKULAM	THIRUVANNAMALAI	4.69	4.50	8.59	4.72
	GOLLAPALLY	VELLORE	4.94	4.35	8.85	4.55
	KARUNKUZI	KANCHEEPURAM	3.53	3.23	7.73	3.55
	KILADAYALAM	VILLUPURAM	3.84	3.21	7.81	3.69
	KILNACHIPATTU	THIRUVANNAMALAI	4.84	4.20	8.73	4.86
	KRISHNAGIRI RES	KRISHNAGIRI	2.58	2.17	6.57	2.59
	CUDDALORE	CHIDAMBARAM	4.28	3.88	8.16	4.49
	MELUMALAI	KRISHNAGIRI	2.66	2.25	6.93	2.71
	PALUR	CUDDALORE	4.05	3.91	8.19	4.01
	THIRUKOILUR FCS	VILLUPURAM	3.47	3.19	7.72	3.40
	VANIYAR RESERVOIR	DHARMAPURI	3.44	2.88	7.38	3.20
	THIRUTHANI (EWS)	THIRUVALLUR	4.99	4.91	9.16	4.61

Fig 5.4: RMSE is calculated for four principle methods

From Fig 5.4 we could understand from the study that FAO Penman Monteith methods gives better accurate result. The mere best model when compared to FAO PM Method is Blaney-Criddle.

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