International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

Estimation of Reference Evapotranspiration using Cropwat For Kadam Watershed

Sreenivasa Rao.G, Giridhar MVSS, Venkata Laxmi.K, Shyama Mohan

Abstract: Due to the overuse of available water resources, it has become very important to define appropriate strategies for planning and management of watershed. The objective for the study is determination of reference evapotranspiration using CROPWAT 8.0 software in GIS environment, which includes a simple water balance model and one of the main component part of the hydrologic cycle, which allows the simulation of crop water stress conditions and estimation of yield reductions based on well-established methodologies. This paper focused on the estimation of reference evapotranspiration using Cowpat 8.0 .

Keywords: GIS and Cropwat

I. INTRODUCTION

CROPWAT is an irrigation management and planning model simulating the complex relationships of on-farm parameters the climate, crop and soil. The CROPWAT facilitate the estimation of the reference evapotranspiration, crop evapotranspiration, irrigation schedule and agricultural water requirements with different cropping patterns for irrigation planning (Nazeer2009). The estimate of reference evapotranspiration is an important in Crop water requirement and development of irrigation scheduling.

The Penman–Monteith equation for computation of daily reference evapotranspiration assumes the reference crop evapotranspiration as that from a hypothetical crop with 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 (Allen et al. 1998). It is expressed as:

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma * \frac{900}{(T+273)} * u_2 * (e_s - e_a)}{\Delta + \gamma * (1 + 0.34 * u_2)}$$

Where,

ET_0 = is reference evapotranspiration (mm day-1)

R_n is net radiation at the crop surface (MJ m^{-2} day^{-1})

G is soil heat flux density (MJ $m^{-2}day^{-1}$)

T is mean daily air temperature at 2 m height (°C)

u_2 is wind speed at 2 m height (m s^{-1})

e_s is saturation vapour pressure (kPa)

e_a is actual vapour pressure (kPa)

(e_s - e_a) saturation vapour pressure deficit (kPa)

Δ is slope vapour pressure curve (kPa $°C^{-1}$)

γ is psychometric constant (kPa $°C^{-1}$).

Revised Manuscript Received on February 28, 2020.

* Correspondence Author

Dr. G. Sreenivasa Rao *, Department of Civil Engineering, Maturi Venkata Subba Rao (MVSR) Engineering College, Hyderabad, India.

Dr. MVSS Giridhar, CWR, IST, JNTUH, Hyderabad, India.

K. Venkata Laxmi, Assistant Professor, College of Horticulture, Rajendranagar, Hyderabad, India.

Shyama Mohan, RS, CWR JNTUH, Hyderabad, India.

II. STUDY AREA

The study area was taken as middle Godavari G- 5 Sub – basin and is known as Kadam watershed. The middle Godavari sub-basin lies between latitudes 18 ^{0}20' N and 19^{0}25' N and longitudes 77 ^{0} 36' and 79 ^{0} 56 ' East. The study area consists of eight rain gauge stations such as Gudihatnur, Utnoor, Indravalley, Khanapur, Neradigonda, Boath ,Bazarhatnoor and Ichoda under old Adilabad District.TS, India. Metrological data collected from RARS, Jagityal, TS.

III. METHODOLOGY

Evapotranspiration is one of key essential parameters in the hydrological cycle. It is calculated using the software CROPWAT. The input for the computation of ET requires metrological variables such as normal maximum temperature, minimum temperature, sunshine hours, relative humidity, wind speed and rainfall. The metadata like temperature was not available for the most of the stations hence the common available temperature data was taken into consideration. The metrological database has been generated for 15 years on daily basis. Using the CROPWAT software reference evapotranspiration was calculated for the entire study area which uses FAO 56 Penman Monteith method. The latitude and longitude values for the above stations were collected and the geo reference points for the same were registered and rectified in GIS software. Reference evapotranspiration values have been exported to GIS environment to build the topology. The raster layer developed has the cell size of a 0.002 of reference evapotranspiration. Reference evapotranspiration maps were then prepared for overall study area on monthly basis and yearly basis.

IV. RESULT AND ANALYSIS

The reference evapotranspiration (ET_0) calculated using daily data such as minimum-maximum temperature, humidity, wind speed, bright sunshine hours for a period of 2000-2014 is used in the study. The input to the software is given as daily data for each year and daily ET_0has been calculated which is extracted to output in the excel sheet from the software. Table 1 shows the Daily Reference Evapotranspiration (mm/day) for the Month of January from 2000-2014. The monthly normal maximum $ET_0$is found to be 146.18mm in the month of April 2003 and monthly minimum ET_0 of 68.53 mm in the month of Jan 2007 from the table 2. The maximum total ET_0 is 1250.5mm/year in the year 2002 and minimum total ET_0 is 1119.13mm/year in the year 2008 and shown in the Table 3. Some of the developed reference evapotranspiration maps shown in Fig. 1 to Fig.4

Table 1 Daily Reference Evapotranspiration (mm/day) for the Month of January from 2000-2014

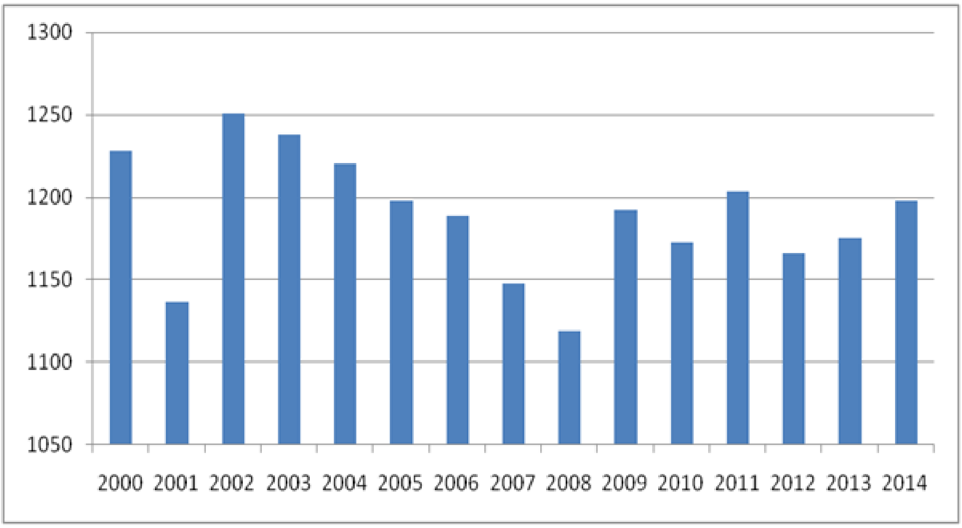
Day	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1-Jan	2.25	2.37	2.29	2.00	2.27	2.53	2.21	1.91	2.18	2.18	1.93	2.10	1.36	2.55	2.21
2-Jan	2.27	1.63	2.05	2.19	2.43	2.43	2.11	1.69	2.10	2.11	2.13	1.36	1.61	2.33	2.17
3-Jan	2.14	1.43	2.17	2.51	1.87	2.14	2.23	2.09	1.86	2.11	2.23	2.07	2.06	2.28	2.33
4-Jan	2.22	2.10	2.30	1.41	2.35	1.94	2.14	1.96	1.92	1.97	2.21	2.20	2.19	2.65	2.23
5-Jan	2.10	2.50	2.37	2.26	2.28	2.22	2.25	2.26	2.20	2.13	2.26	2.12	2.60	2.30	2.43
6-Jan	2.10	2.46	2.23	2.17	2.34	2.47	2.25	2.29	2.31	2.04	2.19	1.98	2.65	2.80	2.38
7-Jan	2.25	2.32	1.33	2.34	1.87	2.45	2.12	2.19	2.16	1.99	2.22	2.11	2.55	2.33	2.47
8-Jan	2.18	2.58	1.99	2.26	2.24	2.34	2.22	2.03	2.15	2.17	2.15	2.05	2.70	1.82	2.44
9-Jan	2.28	2.71	2.38	2.13	2.33	2.33	2.26	2.10	2.35	2.33	2.23	2.25	2.66	1.94	2.31
10-Jan	2.44	2.63	2.53	2.03	2.26	2.31	2.31	2.18	2.33	2.39	2.41	2.16	1.92	2.28	2.32
11-Jan	2.49	2.50	2.50	2.24	2.26	2.24	2.44	2.16	2.25	2.31	2.46	2.21	1.77	2.17	2.33
12-Jan	2.49	2.72	2.49	2.21	2.33	2.20	2.49	2.27	2.30	2.31	2.49	2.23	2.24	2.35	1.87
13-Jan	2.57	2.67	2.40	1.88	2.37	2.21	2.56	2.32	2.38	2.40	1.88	2.39	2.16	2.33	2.03
14-Jan	2.32	2.78	2.47	1.83	2.51	2.20	2.45	2.28	2.34	2.30	1.43	2.35	2.12	2.47	2.30
15-Jan	2.77	2.70	2.64	1.46	2.59	2.36	2.37	2.21	2.40	2.36	1.87	2.64	2.07	2.64	2.31
16-Jan	2.46	2.73	2.59	2.21	2.61	2.60	2.35	2.19	2.34	2.38	2.35	2.54	2.14	2.78	2.52
17-Jan	2.41	2.61	2.72	2.20	2.66	2.61	2.44	2.35	2.40	2.33	2.43	2.48	2.50	2.83	2.32
18-Jan	2.76	2.73	2.71	2.35	2.74	2.25	2.52	2.00	2.39	2.61	2.48	2.34	2.52	2.65	2.13
19-Jan	2.64	2.55	2.72	2.45	2.67	2.28	2.70	2.14	2.37	2.61	2.39	2.45	2.58	2.64	1.86
20-Jan	2.64	2.73	2.58	2.66	2.76	2.21	2.85	2.40	2.46	2.53	2.38	2.53	2.38	2.48	2.28
21-Jan	2.56	2.73	2.79	2.66	2.88	2.51	2.71	2.50	2.67	2.56	2.39	2.52	2.30	2.64	2.45
22-Jan	2.84	2.79	2.75	2.66	3.05	2.64	2.82	2.51	2.80	2.50	2.33	2.44	2.44	2.44	2.51
23-Jan	2.66	2.81	2.58	2.44	2.46	2.86	2.69	2.45	2.74	2.60	2.40	2.57	2.62	2.67	2.27
24-Jan	2.54	2.65	2.97	2.76	2.30	1.61	2.81	2.27	2.04	2.62	2.54	2.75	2.54	2.32	1.58
25-Jan	2.67	2.58	2.64	2.80	2.16	2.15	2.54	2.10	1.55	2.67	2.54	2.83	2.66	2.31	1.98
26-Jan	2.87	2.72	2.91	2.89	1.88	2.40	2.44	2.58	2.29	2.82	2.49	2.72	2.50	1.61	2.52
27-Jan	2.85	2.67	2.70	2.61	1.83	2.76	2.43	2.55	2.12	2.81	2.54	2.82	2.54	1.64	2.50
28-Jan	2.91	2.59	2.65	2.90	2.62	2.17	2.35	2.56	2.50	2.77	2.57	2.77	2.56	1.52	2.62
29-Jan	2.69	2.83	2.70	2.79	2.64	1.86	2.45	2.35	2.51	2.79	2.14	2.80	2.62	2.15	2.71
30-Jan	2.80	2.43	2.60	2.78	2.25	2.28	2.55	1.68	2.45	2.88	2.43	2.89	2.52	2.50	2.70
31-Jan	2.72	2.75	2.55	2.87	2.53	2.22	2.60	1.96	2.56	2.32	2.66	2.97	2.40	2.45	2.60

Table2 Monthly Reference Evapotranspiration (mm/day) for years 2000-2014

S.No	Month	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
1	January	77.89	79	77.3	72.95	74.34	71.78	75.66	68.53	71.42	74.9	71.15	74.64	72.48	72.87	71.68
2	February	88.52	91.63	90.69	92.63	87.9	89.87	87.96	79.85	79.88	81.98	86	86.32	86.63	87.17	84.18
3	March	120.37	117.98	122.19	123.26	116.64	117.18	114.97	108.27	103.9	106.31	110.89	114.63	107.44	111.43	108.3
4	April	135.25	126.47	132.52	137.72	135.25	123.14	131.22	122.21	122.37	114.89	125.06	130.51	122.84	130.03	111.36
5	May	140.66	120.61	137.78	146.18	140.66	135.28	132.37	134.82	130.25	124.4	130.79	131.91	133.7	139.11	139.65
6	June	110.98	90.49	119.7	119.38	110.98	123.24	112.89	99.23	89.3	129.71	114.48	116.68	113.39	102.28	123.96
7	July	99.46	75.96	119.33	95.38	99.46	91.85	90.54	98.87	95.77	103.35	90.05	105.51	90.94	92.13	100.54
8	August	99.62	85.85	85.69	91.85	99.62	100.27	97.25	106.66	87.44	106.8	106.95	95.17	100.91	87.2	115.66
9	September	111.95	109.26	112.39	104.83	111.95	100.4	106.29	97.64	91.41	111.76	96.08	98.29	96.87	108.33	102.88
10	October	103.01	91.56	102.56	100.59	103.01	96.6	101.02	90.96	101.99	95.37	97.39	105.07	94.05	96.53	100.89
11	November	71.78	79.38	78.96	84.63	71.78	80.19	72.21	76.59	75.24	74.22	76.24	78.68	75.08	78.38	75.03
12	December	68.79	68.1	71.39	68.29	68.76	67.82	66.04	64.22	70.16	68.79	66.87	66.36	71.95	69.55	63.58

Table 3 Yearly Reference Evapotranspiration (mm/day) for the years 2000-2014

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
ETo	1228.28	1136.29	1250.5	1237.69	1220.35	1197.62	1188.42	1147.85	1119.13	1192.48	1172.75	1203.77	1166.28	1175.01	1197.71



Yearly Reference Evapotranspiration for the year 2000 to 2014

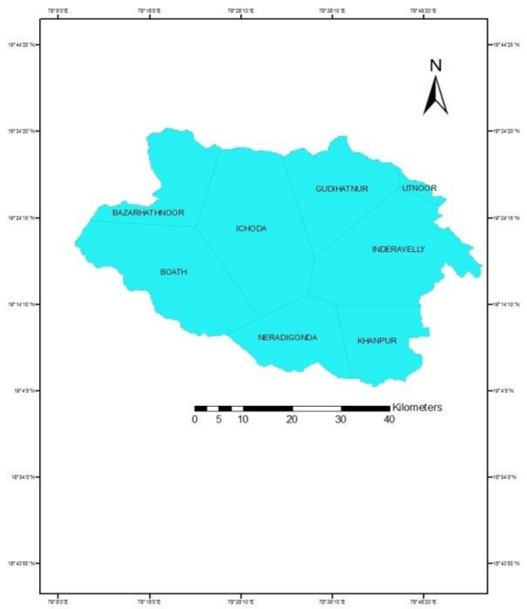


Fig 1 Yearly Reference Evapotranspiration with value of 1119.13 mm per day for 2008

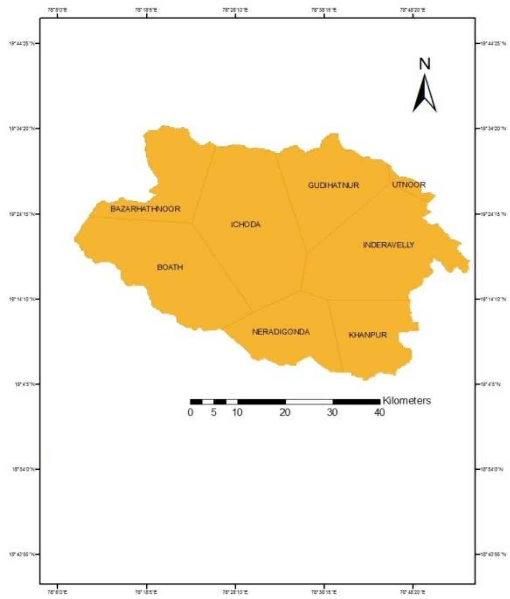


Fig 2 Yearly Reference Evapotranspiration with value of 1250.5 mm per day for 2002

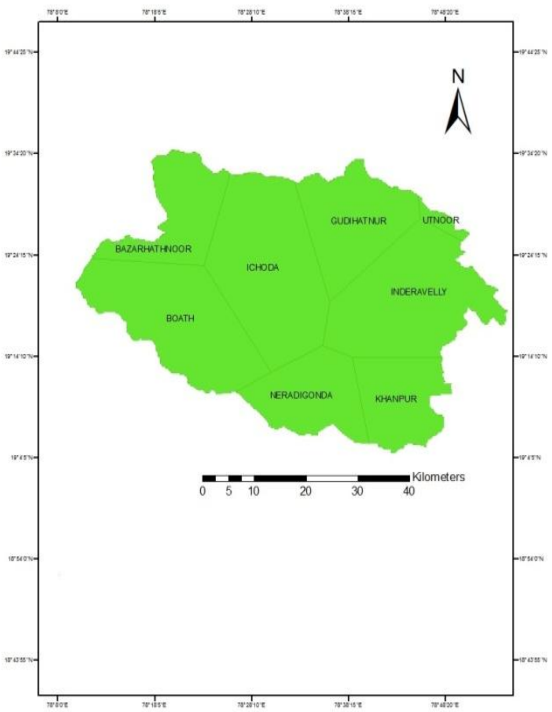


Fig 3 Monthly Reference Evapotranspiration with value 68.04 mm/day for December

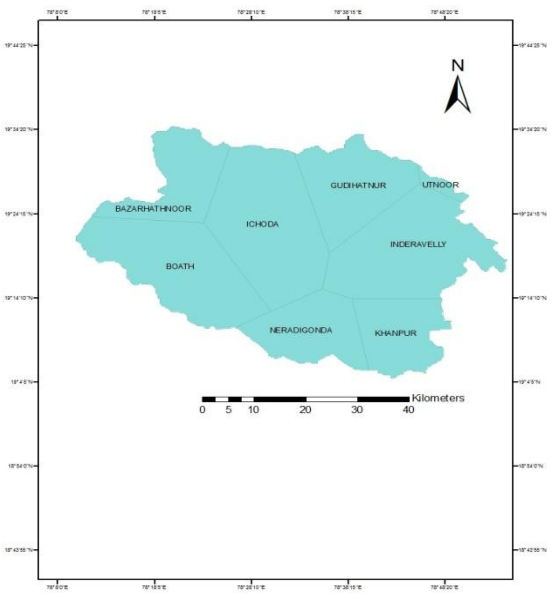


Fig. 4 Normal Monthly Reference Evapotranspiration with value 134.54 mm/day for the month of May

V. CONCLUSION

Reference evapotranspiration for the study area is computed and reference evapotranspiration maps generated in GIS environment for daily, monthly and yearly and this may be useful for developing a rainfall-runoff modelling for the study area for the years 2000 to 2014. Monthly normal reference evapotranspiration and yearly reference evapotranspiration has been computed from the year 2000 to 2014. During the study period maximum yearly reference evapotranspiration is 1250.5 mm/day and minimum 1119.13 mm/day for the year 2008.

REFERENCES

1. Allen et al., (1998) Crop evapotranspiration — guidelines for computing crop water requirements. FAO Irrigation and drainage paper 56. Food and Agriculture Organization, Rome.
2. Dariush et al., Estimation of Evaporation and Transpiration of Wheat Plant in Zaraghan Station Using CROPWAT Model, International journal of Advanced Biological and Biomedical Research Volume 2, Issue 4, 2014: 1362-1370.
3. Hashem et al., (2016), Performance Evaluation and Development of Daily Reference Evapotranspiration Model, Irrigat Drainage Sys Eng 2016.
4. Lindstrom et al., (1997). Development and test of the distributed HBV-96 hydrological model, Journal of Hydrology. Volume 201, Issues 1–4, 20 December 1997, Pages 272-288.
5. Tarate et al., (2017). Estimation of reference evapotranspiration for Parbhani district. International Journal of Agricultural Engineering (10): 51-54.
6. Vivekanand Singh et al., (2006), Reference Evapotranspiration by Various Methods for Kashmir Valley, Journal of Indian Water Resources Society Vol. 26 No. 3- 4, July-Oct., 2006.
7. Xu et al., (2000), Evaluation and generalization of radiation-based methods for calculating evaporation, Hydrological processes Volume 14, Issue 2: 339–349.
8. Xu et al., (2001), Evaluation and generalization of temperature-based methods for calculating evaporation, Hydrol. Process. 15: 305–319.
9. Zeleke et al., (2012). Evapotranspiration Estimation using Soil Water Balance, Weather and Crop Data. In A. Irmak (Ed.), Evapotranspiration: Remote Sensing and Modeling: 41-58.
10. Zhao et al., (2013). ―Evapotranspiration estimation methods in hydrological models‖ J. Geogr. Sci. 2013, 23(2): 359-369.

AUTHORS PROFILE

Dr. G. Sreenivasa Rao received his Bachelor of Technology degree in Civil Engineering from the Sri Venkateswara University, AP. Masters Degree in Water Resources from Jawaharlal Nehru Technological University in 1992. Doctorate in Civil Engineering from JNTUH, Hyderabad in the year 2019. Currently he is working as Associate Professor, Department of Civil Engineering, Maturi Venkata Subba Rao (MVSR) Engineering College, Hyderabad.

Dr. M.V.S.S.Giridhar is presently Professor of Centre for Water Resources, Institute of Science and Technology, JNTUH, Hyderabad. His area of research is on Remote Sensing and GIS applications in surface water and ground water. He has published 153 research papers in National & International Journals. He guided two Ph.D students and four students are doing research. He successfully completed nine R&D projects and currently handling three research projects, he constructed twenty three recharge bore wells in the university campus and every year more than 10.0 crore litres of rain water is being harvested and recharged into the aquifer after proper filtration.

K.Venkata Laxmi, working as Assistant Professor, college of Horticulture, Rajendra nagar, Hyderabad. She did M.Sc (Ag) in Horticulture from ANGRAU. She was Gold medalist in PG. Her area of research is fruit sciences. Previously she worked as Scientist and Farm Superintendent, Fruit Research Station, Sangareddy, TS. Her area of research on Carunda fruit. Shyama Mohan, Research Scholar, Institute of Science and Technology, Centre for Water Resources, JNTUH, Hyderabad.