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Selection of appropriate method for computation of potential evapotranspiration and assessment of rainwater harvesting potential for middle Gujarat

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ABSTRACT

Daily weather data recorded at agrometeorological observatory, Gujarat Agricultural University (GAU), Anand during 1958-99 have been used to compute weekly and monthly potential evaporation by the Christiansen (1968) method and potential evapotranspiration by the Thornthwaite (1948), Turc (1960), Modified Penman (1975), FAO Blaney-Criddle (1977), Hargreaves (1985) and Penman-Monteith (1990) methods. The computed values are compared with average observed values of pan evaporation. For computation of potential evapotranspiration at weekly basis, the Hargreaves method was found to be the best (r = 0.94) with highest model @ratio (F = 401.84). This has been used for assessment of rainwater harvesting potential by USDA, SCS, CN method. The paper briefly presents results of studies on onset of the effective monsoon and climatic water balance for the region.

Key words : Pan evaporation, Potential evapotranspiration, Rainwater harvesting potential, Effective monsoon

Gujarat State shows a large spatial and temporal variation in annual rainfall ranging between 350 and 2000 mm with coefficient of variation of 30 to 85%. Rainfall received over arid and semi-arid areas is scanty and erratic during the southwest monsoon season. Thus there is a need to develop strategies to improve collection of runoff water whenever possible and its efficient use to increase agricultural production in the semi-arid middle Gujarat region.

With regard to assessment of water requirement for irrigation scheduling of crops under limited scarce irrigation water resource appropriate selection of the method based on analysis of time series of meteorological parameters is an important step. Khandelwal *et al.*, (1996a, 1996b) used Penman - Monteith formula (reported in 'CROPWAT' by Smith (1992)) in Mahi Right Bank Canal Command (MRBC) and Ukai Kakrapar Command Area (UKCA) respectively in Gujarat for rescheduling of canal irrigation in order to restrict increasing water logging and soil salinity in the regions (Smith, 1992).

MATERIALS AND METHODS

Daily meteorological data for the period of 1958-99 collected at the agrometeorological observatory of the Gujarat Agricultural University, Anand (latitude 22°35' N, longitude 72°58' E and at altitude of 45 m above mean sea level) have been used to compute weekly and monthly mean values. These were used for computation of potential evaporation (PE) by Christiansen and potential

evapotranspiration (PET) by Thornthwaite, Turc, Modified Penman, FAO Blaney-Criddle, Hargreaves and Penman-Monteith methods (Khandelwal, 1999). The PE and PET values were statistically compared with corresponding averages of observed average pan evaporation data. Standard correlation and regression analysis, the paired difference 't' test and the Komlogorov Smrinov test using the software 'STATG' ver 2.6 were performed. The daily rainfall (1958-99) data were used to compute average rainwater harvesting potential of the region by in USDA, SCS, CN method and also onset of effective monsoon and water balance in the region.

Rainfall characteristics

The mean date of onset of effective monsoon in the region is June 29 at 68% probability (Table 1). Average date of ending of effective monsoon in the region is Sep 23. The expected date and duration of critical dry spells and rainfall receipt during different wet spells following Ashokraj (1977) are presented in Table 2 and 3 respectively.

Evaporation and evapotranspiration:

Summary of statistical analysis of computed potential evaporation and potential evapotranspiration by different methods with average observed pan observation is presented in Table 4. Comparison of computed weekly potential evaporation by Christiansen method with observed weekly pan evaporation yielded high correlation (r=0.91) and high model 'F' ratio (240.71) but it was not acceptable by test of significance.

Weekly water balance for the region is presented in Fig 1. Rainfall (688 mm) during the period of 12 weeks (standard weeks

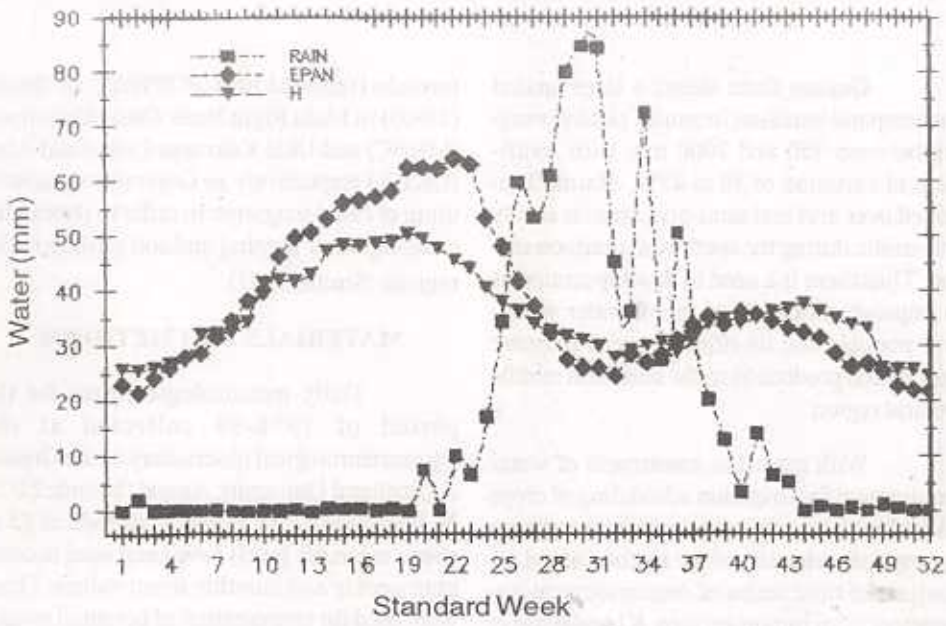

Fig. 1 : Weekly water balance for Anand (middle Gujarat) based on average of weekly data (1958-98)

26 to 37) is in excess of pan evaporation (363 mm) or PET by Hargreaves method (373 mm) respectively. Hence this excess rainfall of the order of 350 mm can be easily harnessed for use in the post monsoon period during the critical dry spell (Table 2).

Harvestable runoff

Computation of harvestable runoff based on event wise daily rainfall under different sets of curve numbers (Hydrologic Soil Cover Complex 'B') and different antecedent moisture conditions along with corresponding average rainfall (1958-99) during the selected months (May to Nov) are presented in Table 5. On an average, for antecedent moisture condition II, runoff ranging from 199 mm (CN=59) to 427 mm (CN=88) is likely to occur under prevailing conditions (regardless of dormant or growing season). But for AMC III, expected runoff varies from 112 mm (CN=59) to 450 mm (CN=88). Growing period yielded slightly less runoff ranging from 92 to 430 mm. Decrease in expected available runoff during growing season is attributable to use of rainwater in meeting actual evapotranspiration requirements.

Table 1 : Onset and withdrawal of effective monsoon

Criteria	Probability (P=0.50)	Probability (P=0.68)
Earliest date of onset of effective monsoon	Jun 14	Jun 07
Mean date of onset of effective monsoon	Jun 30	Jun 29
Latest date of onset of effective monsoon	Jul 17	Jul 22
Average date effective monsoon ends	Sep 23	
Standard deviation	23 days	

Table 2 : Date of onset and duration of critical dry spells

Spell	First	Second	Third
Date and duration of critical dry spell (CDS)	Jul 16 (25 days)	Aug 16 (31 days)	Sep 09 (20days)

Table 3 : Rainfall during different wet spells

Spell	First	Second	Third	Fourth
Rain during wet spell	352 mm (Jun29–Jul 19)	254 mm (Aug13– Aug 26)	157 mm (Sep18– Sep 29)	72 mm (Oct 01–Oct 06)

Table 4 : Statistical analysis of comparison of computed PE and PET by different methods with average observed pan evaporation

Methods	Mean	Intercept	Regression Coefficient	Correlation Coefficient	F Ratio	Decision
Christiansen	10.6	-1.45	2.25	0.91	240.71	Reject
Thornthwaite	1.9	-0.12	0.38	0.75	65.15	Reject
Turc	10.2	7.31	0.54	0.71	50.83	Reject
Modified Penman	2.5	1.51	0.18	0.83	109.98	Reject
Blaney Criddle	6.7	3.85	0.52	0.67	40.00	Reject
Hargreaves	5.1	2.19	0.54	0.94	401.84	Accept
Penman-Monteith	4.7	1.70	0.56	0.77	73.73	Reject

Table 5 : Average rain and Harnessable runoff by USDA, SCS, CN method for Anand (Middle Gujarat) based on 1958-99 (all units in mm)

Mon	Rainfall	Harnessable Runoff under different periods and curve number (CN)								
		Regular Period			Dormant Period			Growing Period		
		59	77	88	59	77	88	59	77	88
May	24.3	1.1	3.8	8.4	1.6	4.8	9.1	1.5	2.4	8.5
Jun	131.9	18.7	32.1	55.8	12.6	33.1	57.8	12.0	12.6	55.8
Jul	283.0	53.5	65.1	111.6	26.2	68.5	120.5	24.1	18.2	116.1
Aug	253.0	56.0	66.1	104.9	29.3	66.8	111.1	26.3	17.8	106.3
Sep	147.8	27.4	38.8	63.1	18.2	40.8	66.9	17.4	14.2	64.4
Oct	38.2	5.3	8.8	14.5	4.8	9.0	14.7	3.6	6.7	13.5
Nov	163.9	37.0	43.2	68.3	19.4	41.0	69.5	15.9	20.1	65.8

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