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Prediction of water deficit by probability models for Varanasi region in Uttar Pradesh

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ABSTRACT : The water deficit of various frequencies is required for irrigation planning in rainfed areas. The value of water deficit is needed for computing the depth of irrigation for supplementary irrigation to rainfed crops during the dry spell periods. Prediction of annual maximum water deficit value for the same return periods were computed by Gumbel, Log normal, and Log Pearson Type -III distributions and also used as normal distribution. The probability distribution with lowest value of chi-square (X^2) was selected as the best probability distribution. The statistical comparison by Chi-square test for goodness of fit clearly indicated that Gumbel distribution was the best probability model for predicting weekly maximum water deficit for Varanasi region.

KEY WORDS : Water balance, Probability models, Water deficit

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Hydrologists consider maximum daily rainfall of different return periods important for safe and economical planning and designing of small and medium hydraulic structure. Similarly, maximum weekly water deficit of different return periods is important in crop planning in rainfed areas to apply supplementary irrigations or to predict the drought in terms of water deficit. There is no widely accepted procedure to predict the weekly water deficit. However, a hydrological frequency analysis has an application for predicting the future events on probability basis. Frequency analysis of one day rainfall has been attempted for different places (Sharda and Bhushan, 1985; Prakash and Rao, 1986; Bhatt *et al.*,1996). An attempt has been made in the present analysis to estimate the weekly water deficit values for various return periods for Varanasi districts in Uttar Pradesh state by four distributions and to select the best one.

METHODOLOGY

The daily meteorological data (Table A) were recorded at Agriculture Research Station, Banaras Hindu University (Varanasi) for a period of 32 years (1974-2005) were collected for study and also soil characteristics reference evapotranspiration (ETo) was computed on a weekly basis by Pen man-monteith (FAO-56) methods as suggested by Allen *et al.* (1998).Weekly water balance was computed by Thornthwaite and Mather (1955, 1957) methods.

Weekly water deficit (DEF) values were determined by the following expression:

$$DEF = ET_o - AET$$

where,

ET_o = Weekly reference evapotranspiration, mm

AET = Weekly actual reference evapotranspiration, mm

The computing weekly water balance is described in Table A for Varanasi. By computing water balance, we can know the week in which soil moisture deficit or surplus water is available.

The Weibull's method (1939) was used for computation of observed weekly maximum water deficit amounts at the return period of 2, 5,10,25,50 and 100 years, using below given equation

$$P = m/N + 1$$

where ,

P is the return period (year) ,m is the rank number of water deficit events after arranging in descending order and N is the total number of years of record.

The predicted values of annual maximum water deficit for the same return periods were computed by Gumbel, Log normal and Log Pearson Type -III distributions (Chow *et al.*, 1988) and we also used as normal distribution. The probability distribution with lowest value of Chi-square (X^2) is selected as the best probability distribution for predicting the weekly maximum water deficit.

Table A: Normal weekly water balance at Varanasi (1974-2005)

Week No	PPT (mm)	ETo (mm)	AET(mm)	DEF (mm)	WS (mm)
1	2.8	8.3	2.8	5.5	0
2	2.7	8.6	2.7	5.9	0
3	5.1	9.1	5.1	4	0
4	6.6	10.2	6.6	3.6	0
5	4.7	11	4.7	6.2	0
6	6.9	12.1	6.9	5.2	0
7	6.6	14.1	6.6	7.4	0
8	3.5	15.6	3.5	12.1	0
9	2.9	18	2.9	15.1	0
10	2.6	18.9	2.6	16.3	0
11	1.1	23	1.1	21.8	0
12	2	26.4	2	24.4	0
13	1.2	28.6	1.2	27.4	0
14	0.3	33.9	0.3	33.6	0
15	1.2	38.5	1.2	37.3	0
16	1.9	39.9	1.9	38	0
17	3.2	39.7	3.2	36.4	0
18	1.8	43.2	1.8	41.4	0
19	1.5	42.8	1.5	41.3	0
20	6	42.6	6	36.7	0
21	5.4	43.1	5.4	37.7	0
22	5.8	43.5	5.8	37.7	0
23	13	43.8	13	30.8	0
24	22.3	39.1	22.3	16.7	0
25	29.9	35.6	29.9	5.8	0
26	45.5	29.2	29.2	0	0
27	52	25.2	25.2	0	0
28	74.7	23.6	23.6	0	0
29	76.3	22.2	22.2	0	41.9
30	59.6	21.5	21.5	0	38.1
31	59.6	19.6	19.6	0	39.9
32	71.9	21.8	21.8	0	50
33	72.8	21.4	21.4	0	51.5
34	55.1	20.9	20.9	0	34.2
35	66.6	21.6	21.6	0	45
36	63.9	21.3	21.3	0	42.5
37	63.3	19.4	19.4	0	43.9
38	49.2	19.8	19.8	0	29.3
39	27.1	18.7	18.7	0	8.4
40	17.3	18.6	18.6	0	0
41	4.3	17.5	16.6	0.9	0
42	4.7	17	14.8	2.1	0
43	0.9	15.2	11.3	3.9	0
44	3	14.4	10.4	4.1	0
45	4.2	13.9	9.8	4	0
46	1.2	13	7.4	5.5	0
47	0.6	12.1	6.1	6.1	0
48	1.8	11.7	6	5.7	0
49	0	12.2	4.7	7.5	0
50	1.5	10.7	4.7	6	0
51	1.4	10.1	4.2	5.9	0
52	2.1	10	4.5	5.6	0
Total	1021.6	1171.9	566.3	605.5	424.8

Table 1: Computed value of observed and predicted weekly maximum annual water deficit and chi-square test (X^2)

Sr. No.	Probability (%)	Return period (year)	Observed water deficit (mm) Varanasi	Predicted water deficit (mm)E			
				Gumbel	Log normal	Log pearson type III	Normal
1.	50	2	672.05	625.837	643.174	652.425	656.794
2.	20	5	788.25	792.372	874.847	770.28	881.134
3.	10	10	820.45	902.633	1027.63	833.781	998.515
4.	4	25	900.07	1041.95	1220	902.222	1123.648
5.	2	50	1094.24	1145.3	1362.97	946.577	1204.46
6.	1	100	1447.06	1247.89	1505.8	986.422	1277.137
		X^2 =? $(O-E)^2/E$		64.301	190.79	239.36	119.07

All the four probability distribution functions were compared by chi-square (X^2) test for determining the goodness of fit to observed values by following equation:

$$X^2 = \sum (O-E)^2/E$$

where, O is the observed value and E is the predicted value

RESULTS AND DISCUSSION

The computed observed and predicted values of weekly water deficit at different return periods are shown in Table 1. On the comparison, it was observed that, the theoretical value of water deficit computed by Gumbel distribution are in are close agreement to the observed value at Varanasi. To arrive at best probability model for determining maximum weekly water deficit, the Chi-square values for each distribution were also computed which revealed that, lowest Chi-square values was obtained for Gumbel distribution at Varanasi. The statistical comparison by Chi-square test for goodness of fit clearly indicated that Gumbel distribution was the best probability model for predicting weekly maximum water deficit for Varanasi respectively. This is further confirmed from Fig.1, in which Gumbel distribution was found to be very close to the observed weekly water deficit for Varanasi. The observed values of water deficit was higher than predicted values of water deficit by log normal, log pearson type III and normal distribution at the station, while Gumbel distribution gave higher predicted values of water deficit than observed water deficit at Varanasi. Thus, it may be concluded that the Gumbel distribution was found to be the best probability model for predicting weekly water deficit for Varanasi .

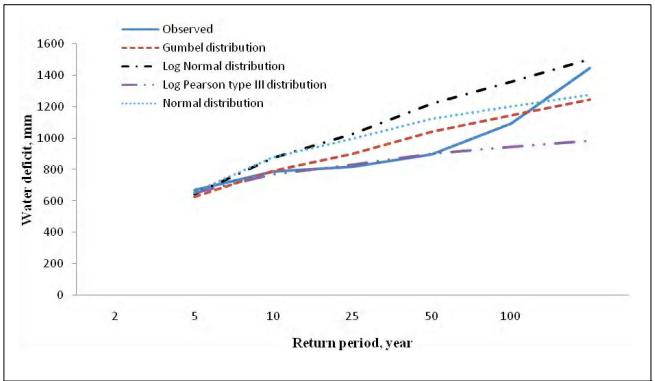

Fig. 1: Comparison of frequency curves of various distributions of weekly water deficit at Varanasi

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REFERENCES

Allen,R.G., Peroira,I.S.,Daes,D. andSmith,M. (1998). Computing crop evapotranspiration, guidelines for computing crop water requirements. FAO Irrigation and Drainage Paper 56, ROME, ITALY. P.300.

Bhatt, V.K., Tiwari, A.K. and Sharma, A.K. (1996). Probability models for predictions of annual maximum daily rainfall for Datia. *Indian J. Soil Cons.,* **24**(1): 25-27.

Chow, V.T., Maidment, D.R. and Mays, L.W. (1988). *Applied hydrology*, Mc Graw Hill Book Company, **11**: 12:371-415.

Jat, M.L., Singh, R.V., Bhakar, S.R. and Gupta, A. (2003). Probability models for prediction of water deficit for Jaipur and Kota in Rajasthan. *Indian J. Soil Cons.*, **33**(2): 173-175.

Prakash, C. and Rao, D.H. (1986). Frequency analysis of rainfall data for crop planning Kota, *Indian J.Soil Cons.,* **14**(2): 23-26.

Sharda, V.N. and Bhushan, L.S. (1985). Probability analysis of annual maximum daily rainfall for Agra. *Indian J. Soil Cons.,* **13**(1): 16-20.

Thornthwaite, C.W. and Matter, J.R. (1957). *Instructions and tabels for computing potential evapotranspiration and water balance*. Pub. in Cli. Lab. of Cli.Elmal., New Jersey, Vol. **10**. No.3.

Thornthwaite, C.W. and Mather, J.R. (1955). The water balance climate. 8 (1). Dresel Inst. of Tech., New Jersey, U.S.A.104pp.

Weibull, W. (1939). A stastical theory of the strength of materials. Ing. Vetenskaprakad Handi (Slockh) pp.151-159.

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