

Frequency analysis of water deficit for crop planning in Gujarat

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ABSTRACT

The frequency analysis of extreme weekly water deficit in different Agro-climatic Zones of Gujarat using the three most common distributions have been computed. χ^2 test for goodness of fit of the observed data to the theoretical distribution was also performed. The distribution that gave the lowest chi-square value has been selected as the best for that location and the predicted maximum weekly water deficit values have been reported.

Key words: Extreme, agro-climatic zone, distributions, return period.

Extreme values of any hydrological variables are important from designing and planning point of view, as it is the extreme, which plays a deciding role in success or failure of any design. During the past years many investigators (Gupta, 1992; Kaledhonkar et al., 1996; Sharma, 1997; Kumar et al., 2000; Suresh, 2003) have analysed the rainfall, flood, drought and other climatic parameters for probabilistic estimates. However, no study was made on water deficit for this region. With this in view, using three well-known extreme probability distribution functions, the extreme weekly water deficit data for Gujarat were analyzed.

MATERIALS AND METHODS

Frequency distribution analysis of largest water deficit, obtained through water balance, during monsoon season was carried out for the selected fifteen stations from eight agro-climatic zones of Gujarat. The study was based on largest weekly water deficit data to understand the distribution pattern of extreme value at the selected stations representing the region and thereby making possible selection of the required water deficit rate for various return periods that may be used in the planning and design of water resource development projects for drought prone areas.

The analysis was preceded by test criterion for adequacy of length of record. The adequacy of length of record was determined following Mockus (1960):

$$Y = (4.30 t \log_{10} R)^2 + 6.0 \quad \dots(1)$$

where,

Y = minimum acceptable years of record

t = student's statistical value at the 95% level of significance with (Y-6) degrees of freedom

R = ratio of magnitude of the 100 years event to the 2 years event

Methods of frequency analysis

Frequencies of extreme weekly water deficit have been evaluated by fitting the data to the extreme value frequency distribution functions. Three most commonly used extreme probability functions viz. (i) Gumbel for maxima, (ii) Weibull for maxima, and (iii) log Pearson Type-III were selected and the distribution that best fitted the data have been used for determining the extreme values at different return periods (probabilities).

Test for goodness of fit of probability distributions

Chi-square test was selected among the most commonly useful procedures for testing goodness of fit test. The test statistic (χ^2) has been estimated from the expression:

$$\chi^2 = \sum_{i=1}^k \frac{(O_i - E_i)^2}{E_i} \quad \dots(2)$$

where,

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Table 1: Adequacy of length of record for frequency analysis of water deficit data at different stations

Station	Water deficit _{100 yr} , mm	Water deficit _{2yr} , mm	$R=WD_{100yr}/WD_{2yr}$	Student's t value	Required length of record, years
Kothara	62.28	26.49	2.35	1.860	14.62
Radhanpur	53.98	25.14	2.15	1.895	13.11
Rajkot	65.13	28.89	2.25	1.860	14.06
Amreli	50.52	15.32	3.30	1.753	21.24
SK Nagar	55.46	18.42	3.01	1.771	19.26
Khedbrahma	39.04	12.95	3.01	1.771	19.29
Arnej	53.79	19.49	2.76	1.796	17.55
Dhandhuka	50.56	18.49	2.73	1.796	17.34
Junagadh	52.60	17.94	2.93	1.782	18.78
Mahuva	56.57	22.56	2.51	1.833	15.72
Anand	48.05	12.98	3.70	1.734	23.98
Nawagam	49.69	12.79	3.89	1.729	25.10
Bharuch	50.82	21.64	2.35	1.860	14.73
Surat	38.33	10.06	3.81	1.734	24.75
Navsari	37.70	9.95	3.79	1.734	24.62

Table 2: Best fit frequency distribution for observed maximum weekly water deficit

Station	Log Pearson Type III	Gumbel (maxima) Chi-square (χ^2) value	Weibull (maxima)
Kothara	2.0	1.2	1.6
Radhanpur	1.2	1.6	4.4
Rajkot	1.2	1.2	1.2
Amreli	6.8	10.8	13.2
SKNagar	2.8	2.8	6.4
Khedbrahma	4.8	9.6	24.0
Arnej	6.8	10.8	13.2
Dhandhuka	8.0	8.0	4.8
Junagadh	2.8	3.2	1.6
Mahuva	6.0	6.8	4.0
Anand	6.8	8.0	7.6
Nawagam	8.2	8.4	7.2
Bharuch	4.0	9.2	7.6
Surat	5.2	4.4	3.2
Navsari	2.0	4.0	2.1

Chi-square (χ^2) value for DF=5 Tabulated value at 5% =11.1 and at 1% = 15.1

k = number of years

O_i = observed values in i^{th} year

E_i = expected value in i^{th} year

The water deficit data occurrences at 1, 2, 5, 10, 20, 50 per cent levels were worked out. The data were analysed by a computer-based routine VTFIT package for fitting probability distribution function that also provides goodness of fit tests.

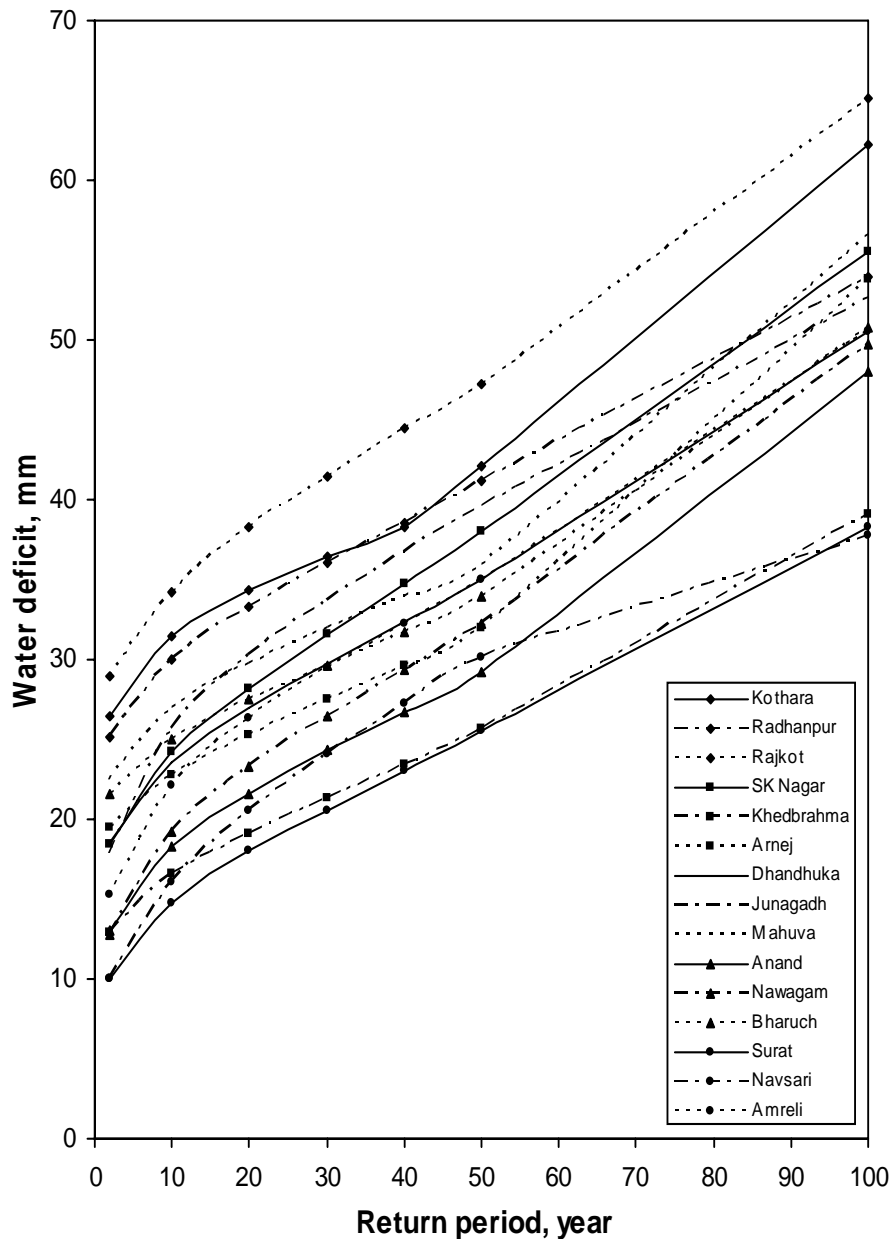


Fig. 1 : Frequency distribution of maximum weekly water deficit during rainy season under different agro-climatic zones of Gujarat

RESULTS AND DISCUSSION

Test of adequacy of record

The results of adequacy of length of record (Table 1) indicate that water deficit data considered for extreme value analysis is adequate, as required length of record for each station is within the range of data considered for the respective station.

Frequency distribution of water deficit

All the selected probability distributions fit the extreme weekly water deficit data well, since their Chi-square values are within the critical limits at 0.05 level of significance. To arrive at best probability model for determining seasonal maximum weekly water deficit in different agro-climatic zones, the distributions with

lowest Chi-square value were sorted out (highlighted in Table 2). Results of best-fit frequency distribution revealed that at Radhanpur, Amreli, Khedbrahma, Arnej, Anand, Bharuch and Navsari only Log Pearson Type-III distribution; at Dhandhuka, Junagadh, Mahuva, Nawagam and Surat only Weibull (maxima) distribution and at Kothara only Gumbel distribution fitted closest to the observed data. Log Pearson type-III and Gumbel distribution gave closest fit to the observed data at SK Nagar. All the three distributions fitted closest to the observed data at Rajkot. The comparison of Chi-square test of best fit distributions clearly indicates that Log Pearson Type-III distribution is the best probability model for predicting weekly maximum water deficit at Radhanpur, Rajkot, Amreli, SK Nagar, Khedbrahma, Arnej, Anand, Bharuch and Navsari. Weibull (maxima) fitted best at Dhandhuka, Junagadh, Mahuva, Nawagam and Surat while Gumbel at Kothara.

Frequency distributions of weekly maximum water deficit at different return periods obtained by using the best probability model selected above are shown in Fig. 1. Weekly maximum water deficit obtained from the long term historical data can be used for designing of protective/life saving irrigation systems

and water resource structures in drought prone areas of Gujarat

REFERENCES

- Gupta, S.K. (1992). A comparison of frequency analysis procedures for rainfall data analysis. *India J. Agril. Engg.*, 2(3):197-202
- Kaledhonkar, M.J., S.K. Kamra, R.K. Yadav, and K.N. Tiwari. (1996). Probability of historic drought for south- western Orissa in India. *J. Indian Water Reso. Soc.*, 2(4):19-24
- Kumar, D., Y. Chandola, and R. A. Rastogi. (2000). Comparison of probability distribution for analysis of data. *Indian J. Soil Cons.*, 28(2):110-116
- Mockus, V. 1960. Selecting a flood frequency method. *Trans. ASAE*. 3(1):48-54
- Sharma, T.C. (1997). A drought frequency formula. *Hydrol.Sci. J.*, 42(6):803-814
- Suresh, R. (2003). Probability model for predicting annual maximum daily rainfall for Pusa farm (Bihar). *Indian J. Soil Cons.*, 31(1):84-85