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Frequency analysis of rainfall deviation in Dharmapuri district in Tamil Nadu

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The 10 years (2004-2013) daily rainfall data for Dharmapuri district was collected from the TWAD (Tamil Nadu Water Supply and Drainage Board) to analyse the nature of distribution and frequency of rainfall. The average annual rainfall for 10 years data was calculated as 506.78 mm and average annual rainy days was 28.10. The maximum monthly rainfall (264.2 mm) was received during the month of June to September which was mostly by southwest monsoon. The maximum rainy days were in the month of September (15 days). The rainfall received during the winter, summer, southwest and northeast monsoon seasons were 17.16, 97.96, 233.82 and 157.84 mm respectively. Rainfall frequency analysis was done by Weibull's method reveals that an annual rainfall of 757.55 mm can be expected to occur once in 11 years at a probability of 9.1 %. The monthly dependable rainfall (p>68 %) is expected to occur in every year in the month of September to October.

[**Keywords**: Rainfall distribution; Weibull distribution; Rainy days; Frequency analysis]

Introduction

India is predominantly an agricultural country with about 60 % of the cultivated under rain fed conditions[1]. Among other factors, rainfall variability has major implications on every country's economic prosperity. Hence, it is imperative to under the distribution and frequency of rainfall in an area. In addition, to irrigation and crop planning this information is also useful for identifying moisture availability periods, introduction of new crops in an agro-ecological zones, developing drought index, designing water harvesting and drainage structures.

Probability distributions are widely used for understanding the rainfall distribution and computation of assumed rainfall. A number of studies have been conducted for location specific agricultural planning in general and crop planning in particular by analyzing daily, weekly, monthly, seasonal and annual rainfall data[2].Suggested cropping system for Doon valley during rainy and winter crop seasons on the basis of expected amount of rainfall at 80 per cent probability level[3].Analyzed daily rainfall data for crop planning in semi-arid tropics. Similar analysis of rainfall data has been done for crop planning in coastal, semi-arid, dry farming and Himalayan foot hill regions[4-7].

Studies have also been carried out to analyze rainfall data using Markov chain model for identifying appropriate cropping systems in different regions[8-11] and eight two parameter distribution functions were studied for sub-humid conditions[12]. Keeping the above views in mind, an attempt has been made to analyze the distribution nature of rainfall and frequency of rainfall which will be useful for proper crop planning.

Materials and Methods

Dharmapuri district is situated in the North western Corner of Tamil Nadu and is bounded by Tiruvannamalai and Villupuram Districts on the east, Salem District on the South, Krishnagiri District on the north and Kaveri river on the west. It is located between latitudes N 11 47' and 12 33' and longitudes E 77 02' and 78 40'. The total geographical area of Dharmapuri district is 4497.77 km^2, (3.46 % of Tamil Nadu geographical area). The climate is generally normal and warm condition. The summer period of March, April, May and June reaching a

maximum temperature of up to 38° C. The temperatures drop in December and the low temperatures continue up to February, touching a minimum of 12° C in January. The district has an average annual rainfall of 895.56 mm. The tropical forests here generally have short shrubs and thorned-plants.

Daily rainfall data for 10 Years (2004 to 2013) was collected from the TWAD (Tamil Nadu Water Supply and Drainage Board) and was converted into annual, monthly and weekly rainfall by arithmetical ways. The relationship between rainfall and rainy days was found by plotting annual, monthly and weekly rainfall against rainy days.

Frequency analysis is used to predict how often certain values of a variable phenomenon may occur and to access the reliability of the prediction. It is a tool for determining design rainfalls and design discharges for drainage works and drainage structures, especially in relation to their required hydraulic capacity. Frequency analysis is based on the past records of hydrologic data. Precipitation is most important and complex phenomena. Rainfall is a random hydrologic process and when arranged in a chronological order, it constitutes the time series of rainfall data.

The probability of each event is calculated by Weibull's method[13]

$P = [M/(N+1)]X100$

Where,

P = the probability of each event in percent

M = the order no. of the each event when the data are arranged in decreasing order

N = the total no. of events in the data series

The return periods (recurrence interval) were calculated by using the formula.

Return period, $T= 1/ P = (N+1) / M$

Results & Discussion

Annual rainfall and rainy days

Annual rainfall data and rainy days for 10 years from 2004 to 2013 is given in Table 1. The maximum and minimum rainfall occurred in 2012 (757.55 mm) and 2009 (156.2 mm) with 45 and 14 rainy days, respectively. The average for these 10 years rainfall was found to be 506.776 mm. It was also observed that 7 years (70 %) received rainfall above average, however, no general trend in rainfall occurrence was observed during these years.

The average annual rainy days was 28.1 which were between 14 days (2010) and 46 days (2005). It was observed that no specific trend was observed, but 4 years were above mean rainy days. The maximum and minimum rainfall received in 2012 (757.55 mm) and 2009 (156.2 mm) had 45 and 14 rainy days respectively. Even though, there is a linear relationship between amount of rainfall and rainy days, the maximum rainfall does not occur in the corresponding rainy days, which may be due to fact that heavy rain occurs in a single day in a during monsoon seasons.

Monthly rainfall and rainy days

The mean monthly rainfall and rainy days are presented in Fig. 1. The maximum rainfall (72.06 mm) was received in the month of October during North east monsoon season. The minimum rainfall of 7.95 mm was received by January and also some pretty reasonable summer showers during April and May. The maximum rainfall (238.33 mm) was received in the month of June to September during southwest monsoon season. The minimum rainfall of 17.16 mm was received by January and February during winter season. The mean monthly rainfall was 42.23 mm and the month except January and February received below the mean. The number of rainy days goes in hands with the mean monthly rainfall. The rainfall received during the winter, summer, southwest monsoon and northeast monsoon are 17.16, 97.96, 233.82 and 157.82 mm respectively (Fig. 2). It can be concluded that maximum rainfall was received during southwest monsoon.

Table 1. Annual rainfall and rainy days for a period of 2004-2013

Year	Annual rainfall, mm	Number of rainy days
2004	269.6	16
2005	652.3	46
2006	530.6	26
2007	587.3	24
2008	392.5	15
2009	156.2	14
2010	521.8	26
2011	521.6	34
2012	757.55	45
2013	678.3	35
Mean	**506.775**	**28.1**

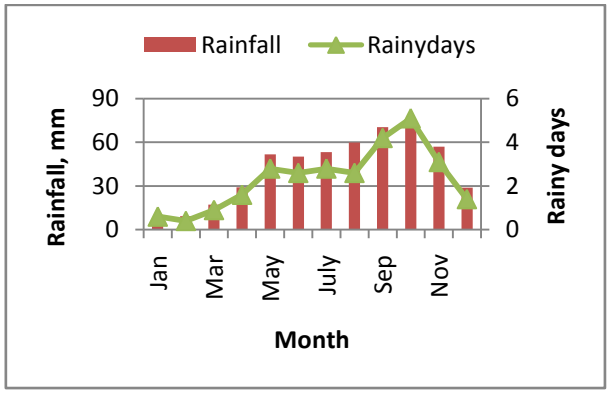

Fig. 1. Mean monthly rainfall & rainy days for the period of 2004 to 2013

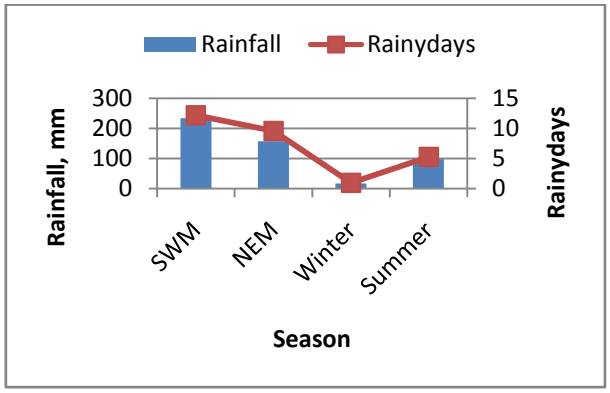

Fig. 2. Seasonal distribution of rainfall and rainydays

Weekly rainfall and rainy days

Weekly rainfall and rainy days against standard week was plotted in Fig. 3. From the figure, it was observed that the variations in weekly rainfall showed fluctuations up to 36th week. There after rainfall showed an increasing trend and gradually decreased to the 52nd week.

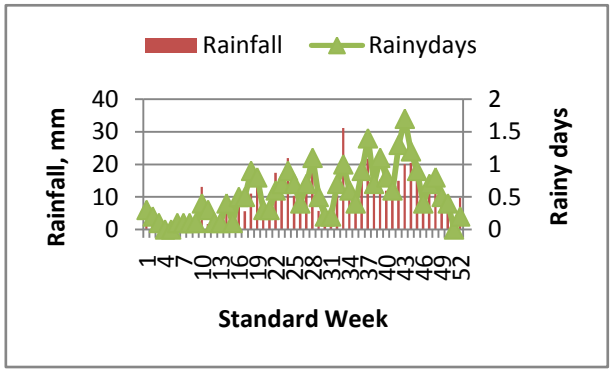

Fig.3.Mean weekly rainfall & rainy days for the period of 2004 to 2013

The maximum weekly rainfall was recorded in the 33rd week (31.15 mm) followed by 24th week (21.89 mm). The maximum weekly rainfall was received in the 4th week and followed by 5th week (zero rainfall). The 24 weeks (46 %) received a rainfall less than the average weekly rainfall 9.75 mm. It can be observed that the weekly rainy days moves up and down and reaches the maximum in 43rd week. The maximum number of rainy days was recorded from 26th to 28th week. The weekly rainfall was classified in to 6 classes and number of weeks under each classes (Table 2). It can be observed that most of the weeks the rainfall is less than 20 mm (90 %).

Table 2. Number of weeks under different amount of rainfall

Year	Amount of rainfall (mm)					
	>=0	>20	>40	>60	>80	>100
2004	47	5	0	0	0	0
2005	43	5	0	2	0	2
2006	38	14	0	0	0	0
2007	32	19	1	0	0	0
2008	43	8	0	0	0	1
2009	50	2	0	0	0	0
2010	41	6	2	1	2	0
2011	42	4	5	0	1	0
2012	39	5	5	2	0	1
2013	41	2	4	4	1	0
Total	416	70	17	9	4	4
Mean	**41.6**	**7**	**3.09**	**0.9**	**0.4**	**0.73**

Relationship between rainfall and rainy days

It is generally believed that total rainfall is the function of total number of rainy days. The correlation coefficient between the two revels that there exist a linear relationship between these two. It was revealed that the rain fall was higher than the average in 2007 (587.3 mm) and 2010 (521.8 mm) whereas rainy days in the corresponding years were marginally lower than the average (2007 - 24 and 2010 - 26). Weekly rainfall against weekly rainy days was plotted (Fig.4) and the regression equation was developed between the variables rainfall (Y) and rainy days (X), in which 75 % of the variables will follow this relationship[14-16].

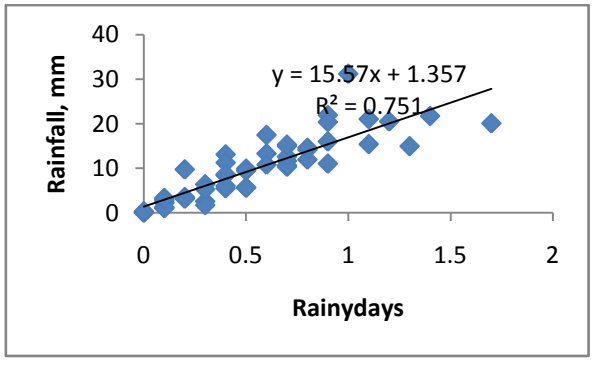

Fig. 4 Relationship between rainfall and rainy days

Rainfall frequency analysis

Rainfall frequency analysis of 10 years annual rainfall data were done by Weibull's method. It revealed that an annual rainfall of 757.55 mm can be expected to occur once in 11 years at a probability of 9.1 % (Fig.5).

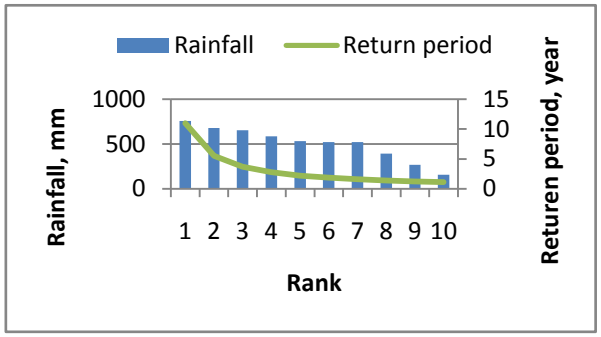

Fig. 5 Probability analysis of annual rainfall for the period 2004 – 2013

It does not mean that this magnitude of rainfall will occur at a regular interval of 11 years, but it only mean that there is every chance for that rainfall to occur once in 11 years. The monthly dependable rainfall (with a probability greater than 68 percent) is expected to occur in every year during the month of April to December with more accumulation during September to October (Table 3). The rainfall that is expected to occur in other recurrence intervals is considered to be undependable. The 11 year frequency of 757.33 mm rainfall can be expected to be equalled or exceeded once in 11 year at a probability of 9.1 %. Like-wise 1.10, 1.22, 1.38, 1.57, 1.83, 2.20, 2.75, 3.6 and 5.50 years recurrence interval at the probability level of 90.9, 81.8, 72.7, 63.6, 54.5, 45.5, 36.4, 27.3 and 18.2 % respectively.

Conclusion

Rainfall is renewable source, highly variable in space and time and subjected to depletion or enhancement due to both natural and anthropogenic causes. The rainfall frequency analysis of ground water modulation in Dharmapuri district can be studies and plotted using Weibulls method. The result of study were analysis for the year (2004-2013) in which the maximum annual rainfall was occur in 2012 (757.55 mm) and annual maximum rainy days occur in 2012 (45 days) and one day maximum rainfall occur in 2007 (102.00 mm). The maximum monthly rainfall (264.2 mm) was received during the month of June to September occurred in southwest monsoon. Here Weibulls method was used for probability distribution function which fitted significantly. The maximum average rainfall was 506.78 mm and average annual rainy days was 28.10. This study gives idea about the prediction of rainfall frequency analysis for ground water modulation for Dharmapuri district to design the irrigation project, drainage project and to study the effect of ground water, storm water management and used in a field of watershed, flood frequency estimation, ground water utilization and sustainability and computing storm water runoff rates.

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Table 3. Monthly Rainfall probability (P) & Return Period(T)

Rank	T	P	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1	11.0	0.09	0.0	0.0	0.0	58.0	63.6	45.6	102.4	0.0	0.0	0.0	0.0	0.0
2	5.50	0.18	0.0	1.60	25.8	13.3	63.7	12.0	35.2	31.0	264.2	192.6	0.0	12.9
3	3.67	0.27	31.5	57.5	0.0	81.0	60.5	67.0	78.5	86.0	53.5	0.0	1.20	13.9
4	2.75	0.36	0.0	0.0	11.5	84.0	78.0	84.5	55.5	75.5	25.5	67.1	25.5	80.2
5	2.20	0.45	26.0	33.0	102	0.0	0.0	81.5	54.5	11.5	80.5	3.5	0.0	0.0
6	1.83	0.55	22.0	0.0	31.8	2.0	28.9	0.0	0.0	0.0	71.5	0.0	0.0	0.0
7	1.57	0.64	0.0	0.0	0.0	7.0	133.5	96.7	42.0	0.0	0.0	50.6	192.0	0.0
8	1.38	0.73	0.0	0.0	0.0	0.0	0.0	90.5	5.5	83.1	61.0	60.5	184.5	63.5
9	1.22	0.82	0.0	0.0	0.0	14.0	34.0	1.0	82.5	185.0	64.5	119.5	161.1	96.0
10	1.10	0.91	0.0	0.0	0.0	31.0	56.0	23.5	75.5	127.5	84.0	226.8	6.0	48.0

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