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Role of Rainfall Variation Trends in Recharge of Groundwater System of Bagh Area, Dhar District, Madhya Pradesh, India.

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Abstract: This paper incorporates an account of rainfall data analysis and its impacts on the ground water system of Bagh area for a period of 25 years (1987 to 2011). Rainfall data have been treated with mathematical and statistical methods of analysis. The mathematical analysis exhibits that maximum precipitation as 1187.0 mm during the year 2006 and minimum rainfall of 289.4 mm in the year of 1987. The computed value of annual average rainfall is 652.48 mm. The departure from the annual average rainfall indicates positive and negative trends, whereas the cumulative departure reflects negative trend of recharge. The statistical analysis of rainfall data includes computation of central tendency Mean (652 mm.), Median (580 mm.), Mode (800 mm.) and Standard Deviation (160 mm.), Coefficient of Dispersion (0.24), Coefficient of Variation (24.53), Coefficient of Skewness (-0.92). These parameters point out rather negative trend of recharge phenomena. The environmental impacts of rainfall factor on ground water system have been discussed. It has been observed that there is need for increase of rainfall frequency.

Key words: Rainfall, Variation trend, Ground water recharge, Bagh area, Dhar district, Madhya Pradesh,India.

Introduction:

Rainfall is one of the most significant meteorological parameter that governs the recharge phenomena of the ground water system. Rainfall phenomena also play an important role in the estimation of water balance status of a basin. Wiesner (1970) has defined rainfall (precipitation) as "the depositing of water from the atmosphere on to the surface. This deposit may be liquid or solid to give the various forms of precipitation". Rainfall records reveal a wide variation range in the amount and frequencies from place to the place. In India, rainfall mostly occurs during the monsoon period. The amount and frequency of rainfall reveal relevance in perceptive of the scope of surface runoff to ground water recharge. Dawar (2012) carried out preliminary hydrogeological investigation in Bagh area of Dhar district, M. P. The variation trend analysis and environmental implications on ground water recharge are discussed in this paper.

Location and Physiography of study area

The Bagh area is situated in Dhar District. within Latitude - 22°20' to 22°25 N and Longitude - 74°45' to 74°50 'E (Survey of India Toposheet No. 46 J/15.Figure-1). Figure 1 Location map of the Bagh area, Dhar district M. P, India.

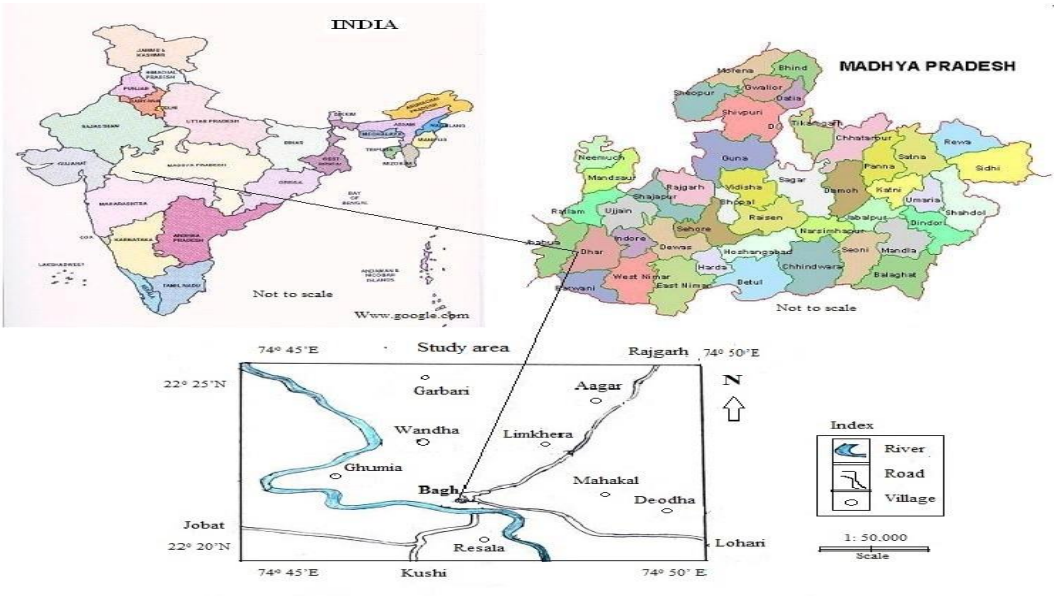

Figure 1. Location of Bagh Study area, Dhar District, Madhya Pradesh, India.

The climate of Bagh area is pleasant and healthy. The summer commences from March and lasts up-to June with a maximum temperature of 47 ^{0} C in the month of May during which hot winds dominant. The winter season is comparatively very mild and lasts for about 8 to 10 weeks from November to February with a minimum temperature of 6^{O} C. The rainfall varies from July to September within a range of 630 to 700 mm. The monsoon provides over 90% of the total annual rainfall.

Rainfall Data Analysis of the Bagh Area :

The annual rainfall data of last 25 years, (1987-2011) have been collected from Dhar District, Ground Water Department. The data are reproduced (Table 1). The rainfall data have been subjected to mathematical and statistical methods of analysis.

1 Mathematical Method :

The mathematical method is commonly used for rainfall data analysis. This method involves computation of the average for the period of specific month or year as arithmetic mean. The determined values are expressed in mm. The range of variation in rainfall is indicated by a stable mean. The annual rainfall data of 25 years indicate that the maximum precipitation during the last two decades was to be 1187.0 mm and minimum rainfall of 289.4 mm during the year of 2006 was noted. The annual average rainfall of the area has been calculated, as total year is 652.48 mm.

Table1: Annual Rainfall, Departure and cumulative departure from the annual average rainfall, in Dhar District (M.P.)

S.No.	Year	Total Rainfall in mm	Departure from Average rainfall	Cumulative departure from average rainfall
1	1987	289.4	-363.08	-393.08
2	1988	412.7	-239.78	-602.86
3	1989	694.4	41.92	-560.94
4	1990	720.5	68.02	-492.92
5	1991	499.0	-153.48	-646.4
6	1992	394.0	-258.48	-904.88
7	1993	776.0	123.52	-781.36
8	1994	940.0	287.52	-493.84
9	1995	471.1	-181.38	-675.22
10	1996	781.0	128.52	-546.7
11	1997	709.0	56.52	-490.18
12	1998	928.0	-24.48	-514.66
13	1999	574.0	-78.48	-593.14
14	2000	290.0	-362.48	-955.62
15	2001	627.0	-25.48	-981.1
16	2002	665.0	12.52	-968.58
17	2003	649.0	-3.48	-972.06
18	2004	731.9	79.42	-892.64
19	2005	437.0	-215.48	-1108.12
20	2006	1187.0	534.52	-573.6
21	2007	1155.0	502.52	-71.08
22	2008	588.0	-64.48	-135.56
23	2009	693.0	40.52	-95.04
24	2010	727.0	74.52	-20.52
25	2011	673.0	20.52	0
Total Rainfall		**16312 mm**		

Average Rainfall = 16312/25 = 652.48 mm.

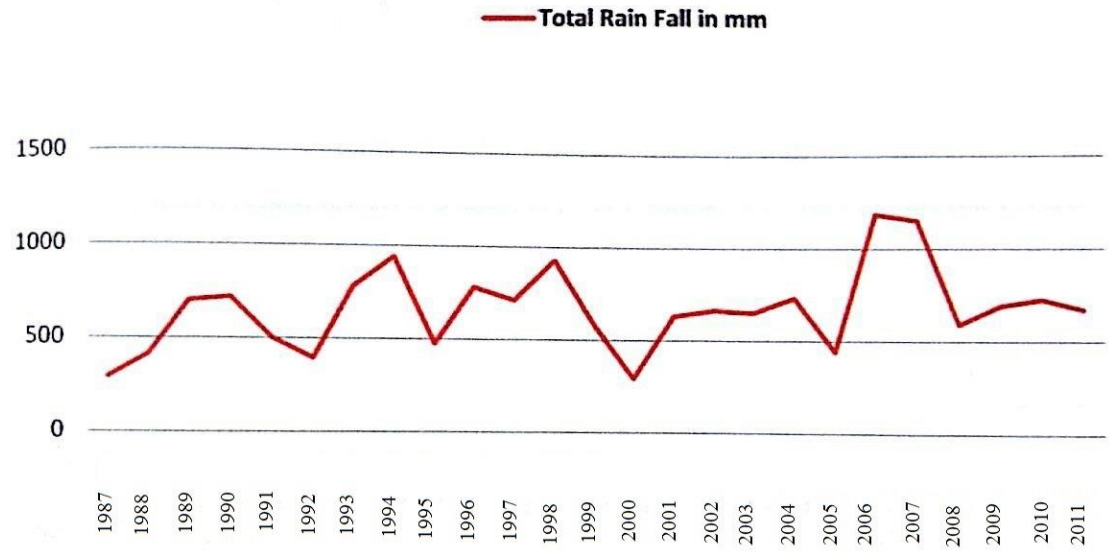

Figure 2. Total annual rainfall (in mm) for the period of 1987-2011.

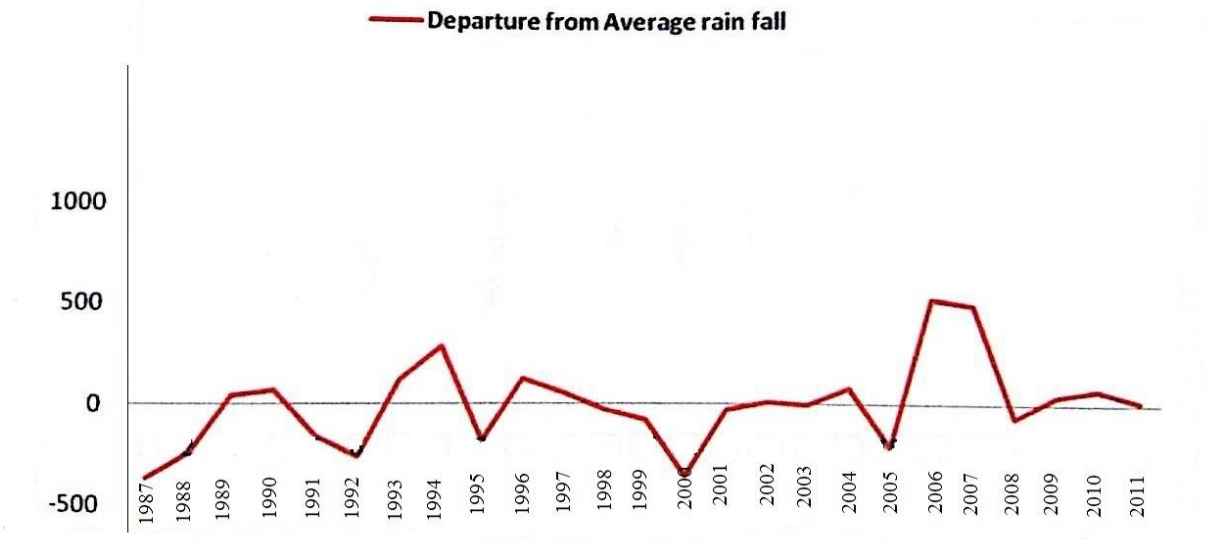

Figure 3. Departure from average rainfall (in mm) for the period of 1987-2011

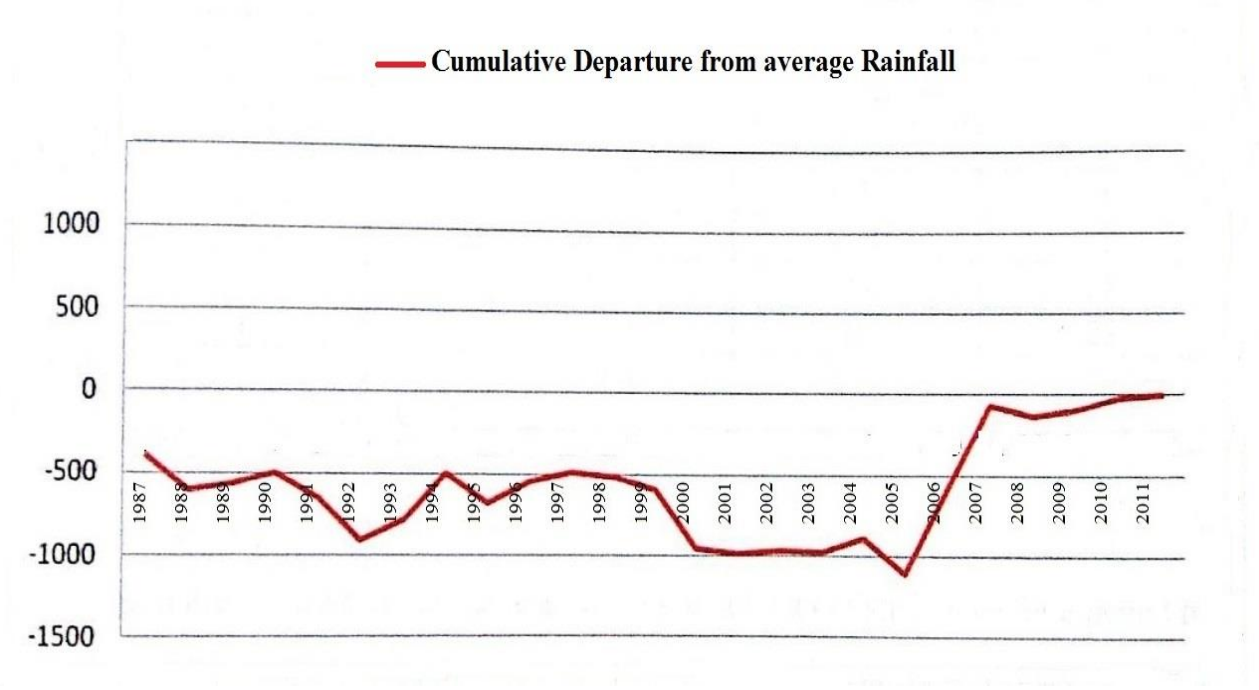

Figure 4. Cumulative Departure from average rainfall (in mm) for the period of 1987-

2 Statistical Method

The statistical method for the analysis of rainfall data of study area for a period of 25 years (1987-2011), has been conducted to determine the central tendencies. (Mean, Median, Mode). Standard Deviation, Coefficient of Dispersion, Coefficient of Variation, Coefficient of Skewness. Following the methods proposed by Davis (1986, 2002). The methods of computing of the rainfall are described underneath:

Table 2. Statistical Analysis of Rainfall Data of Bagh area Dhar District showing frequency distribution :

Class interval	Mid value	Frequency	U=(X-700)/200	FU	U^2	FU^2	Cumulative
200-400	300	3	- 2	- 6	4	12	3
400-600	500	6	-1	-6	1	6	9
600-800	700	12	0	0	0	0	21
800-1000	900	2	1	2	1	2	23
1000-1200	1100	2	2	4	4	8	2

Mean:
Mean for a set of observations is their sum divided by the number of observation. It is calculated by the following formula:

$$\text{Mean} = A + \frac{(\Sigma fu)}{N} \times I$$

Where,
A = Assumed mean = 700
I = Class interval = 200
f = Frequency = fu = -6
N= Total frequency = 25

$$= \frac{700 + (-6)\ 200}{25}$$

= 652 mm.

Median
Median is defined as the variable which divides a set of observations and it is calculated by the use of given formula.

$$\textbf{Median} = I + \frac{i}{f}\left(\frac{N}{2} - C\right)$$

Where,

I = Lower limit of median class = 600

f= Frequency of Median class = 12
i = Magnitude of Median class = 200
c = Cumulative frequency of the class preceding the median class = -21

$= 600 + \frac{200}{12}\left(\frac{25}{2-23}\right)$

= 580 mm.

Mode:

Mode is the value, which occurs most frequently, in a given set of observation and it is calculated by use of given formula.

$$\text{Mode} = L + \frac{f - f_1}{2f - f_1 - f_2} \times I$$

Where,
L = lower limit of the modal class = 700
f= frequency of the modal class = 12
f1 = frequency of the pre modal class = 2
f2 = frequency of the post modal class = 2
I = Interval class =200

$$\text{Mode} = L + \frac{f - f_1}{2f - f_1 - f_2} \times I$$

$$\text{Mode} = 700 + \frac{12 - 2}{2(12)(-2 - 2)} \times 200$$

Mode = 800 mm.

Standard deviation

Standard deviation commonly represented by the Greek latter small sigma (σ) is the positive square root of the arithmetic mean of the squares of the deviation of the given values from their arithmetic mean.

$$\sigma = {}^{I}\sqrt{\frac{(\sum fu_2) - \sum (fu)2}{\sum f - \sum f}}$$

Where,
σ. = Standard deviation
I = Class interval =200
Σf = N = Number of sample =25
Σfu2 = 28
Σfu = -6

$$\sigma = {}^{I}\sqrt{\frac{(\sum fu_2) - (\sum fu)2}{\sum f - \sum f}}$$

$$\sigma = {}^{200}\sqrt{\frac{(28) - (-6)2}{25 \ - 25}}$$

σ = 160 mm.

Co- efficient of dispersion

Whenever we want to compare the variability of the two series which are dispersion but we calculate the co-efficient of dispersion which are pure numbers independent of the units of measurement.

Co- efficient of Dispersion $= \frac{\text{Standard Deviation}}{\text{Mean}}$

$= \frac{160}{652}$

Co-efficient of Dispersion = 0.24 mm.

Co-efficient of Variation

Coefficient of variation has been defined as the percentage variation in the Mean and Standard Deviation is considered as the total variation in the mean.

The coefficient of variation (C.V.) is determined by the following expression-

Co-efficient of variation (C.V.) $= \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$

$= \frac{160}{652} \times 100$

Co-efficient of variation = 24.53 mm.

Co-efficient of skewness:

The co-efficient of skewness indicates the lack of symmetry in the given distribution. It is calculated by following expression-

Co-efficient of Skewness $= \frac{\text{Mean} - \text{Mode}}{\text{Standard Deviation}}$

$= \frac{652 - 800}{160}$

Co-efficient of Skewness = -0.92 mm.

The Rainfall data analysis has been carried out by mathematical and statistical techniques. The mathematical analyses indicate average annual value of Rainfall as 652.48 mm. and trend of recharge variation of ground water system. The statistical analysis reveals that Mean (652 mm.), Median (580 mm.), Mode (800 mm.), Standard Deviation (160 mm.), Coefficient of Dispersion (0.24), Coefficient of Variation (24.53), Coefficient of Skewness (-0.92). These parameters indicate the negative trend.

Environmental Impact of Rainfall Variation

The rainfall variation analysis of Bagh area indicates impacts on phenomena of recharge of ground water system; Rainfall plays a very considerable role in the environmental scenario. The excess rainfall results into flooding of a river and causes damage to vegetation and crops. The scarcity of rainfall results into of water supply and ultimately in drought situation. The average value of rainfall has been determined as 652.48 mm. The rainfall variation plays a major role in the ground water recharge phenomena. The rainfall data analysis of Bagh area reveals a good series of

variation pointing out the positive and negative trends that influence the recharge of the ground water system. It is suggested that scheme of rainfall augmentation is required for implementation in the area

Conclusion:

The rainfall data have been subjected to mathematical and statistical analysis. The mathematical analysis determines a variation trend of rainfall data that indicates range from 289.4 mm. to 1187 mm. and annual average value of rainfall as 652.48 mm. The statistical analysis for rainfall data points out determination of Mean (652 mm.), Median (580 mm.), Mode (800 mm.), Standard Deviation (160 mm.), Coefficient of Dispersion (0.24), Coefficient of Variation (24.53), and Coefficient of Skewness (-0.92). The impacts of rainfall variation in recharge phenomena of groundwater system have been discussed in this paper.

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