

## Rainfall Variability Analysis of Jodhpur Tehsil, Jodhpur, Rajasthan, India.

### Análisis de la variabilidad de las precipitaciones de Jodhpur Tehsil, Jodhpur, Rajasthan, India

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#### ABSTRACT

Rainfall in India shows remarkable temporal and spatial variations. This characteristic affects the ground water levels and water levels of surface water bodies as well. This study attempts to map and analyse the rainfall patterns of 30 years for Jodhpur tehsil by calculating the rainfall deviation with an intent to understand the impact on water logging and availability of water in the region.

Keywords: Rainfall, Jodhpur, Deviation, Temporal variations.

#### RESUMEN

Las precipitaciones en la India muestran notables variaciones temporales y espaciales. Esta característica también afecta los niveles de agua subterránea y los niveles de agua de los cuerpos de agua superficiales. Este estudio intenta mapear y analizar los patrones de lluvia de 30 años para Jodhpur tehsil calculando la desviación de la lluvia con la intención de comprender el impacto en el anegamiento y la disponibilidad de agua en la región.

Keywords: Lluvia, Jodhpur, desviación, variaciones temporales.

#### INTRODUCTION

Jodhpur tehsil lies in the Thar desert to the west of the Aravali hill ranges, which divide the State of Rajasthan in two halves (Upadhyay 2014). Climatically, it belongs to arid zone (Arun K. Sharma, JC Tiwari 2005). Average annual rainfall of the Thar desert is 25.1 cm only (al 2014). Despite lying in such low-rainfall zone, Jodhpur tehsil is sustaining very large population, agricultural and industrial activities.

Over the past few decades, the tehsil had undergone rapid urbanization and thereby land-use changes, which had created qualitative and quantitative challenges related to the water resources in the tehsil. Therefore, the objective of this study is to analyse the rainfall variability of the study area with latest data. Given the above, we believe that the rainfall analysis becomes crucial to ensure its optimal utilization for the sustainable development of the tehsil.

### STUDY AREA

The study area Jodhpur tehsil is located in the southern part of Jodhpur district (Figure 1). In its north, there are 3 tehsils i.e. Shergarh tehsil, Osian tehsil and Bhopalgarh tehsil. To the east is Bilara tehsil and southern border is shared by Luni tehsil and Pali district. Its population is 13,78,224 (Census 2011). Its longitudinal extent is between  $72.6^{\circ}$  E to  $73.3^{\circ}$  E and the latitudinal extent is between  $26^{\circ}$  N to  $26.4^{\circ}$  N. The tehsil is drained by 3 rivers namely Luni, Mithri and Jojari.



Figure 1: Maps of India with Rajasthan & Jodhpur district with tehsils.

### MATERIALS AND METHODS

The rainfall data for the analysis was obtained from the Department of Water Resources, Rajasthan (Department of Water Resources 2020). Microsoft Excel was used for calculations and to generate and analyse patterns. QGIS 3.18.2 was used for generating study area map.

Annual Rainfall Scenario:

The annual rainfall data for the 30 years period from 1990 to 2019 are provided in table 1. Annual Rainfall Data of Jodhpur Tehsil (1990 to 2019) are analysed in Figure 2, table 2 and table 3 provided at the end.

The average, annual rainfall for the 30 years period (1990 to 2019) is found to be 39.3 cm.

Table 1: analysis of annual rainfall data for Jodhpur

Months years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Total Rainfall (mm)
1990	0.0	26.0	0.0	0.0	27.0	0.0	495.0	170.5	96.5	0.0	0.0	0.0	815.0
1991	0.0	0.0	0.0	21.5	0.0	10.0	95.5	95.0	8.5	0.0	0.0	2.0	232.5
1992	21.0	10.2	2.0	0.0	4.4	1.1	82.3	172.0	233.0	0.0	0.0	0.0	526.0
1993	2.0	0.0	0.0	10.0	6.0	18.0	150.0	6.0	35.0	3.0	2.0	0.0	232.0
1994	24.0	0.0	0.0	18.0	6.0	8.0	149.0	135.0	56.0	0.0	0.0	0.0	396.0
1995	0.0	0.0	0.0	0.0	0.0	16.2	283.8	60.0	1.0	13.0	0.0	0.0	374.0
1996	0.0	0.0	0.0	6.0	24.3	148.4	89.8	242.6	10.0	0.0	0.0	0.0	521.1
1997	0.0	0.0	0.0	0.0	19.5	79.0	61.1	317.4	5.1	82.0	8.0	0.0	572.1
1998	0.0	0.0	11.0	20.5	0.0	175.0	36.0	97.5	144.0	93.0	0.0	0.0	577.0
1999	5.0	17.0	0.0	0.0	11.5	57.0	57.0	182.0	11.0	17.0	0.0	0.0	357.5
2000	0.0	0.0	0.0	2.0	5.0	13.0	219.0	32.0	2.0	0.0	0.0	0.0	273.0
2001	0.0	0.0	0.0	5.5	56.5	91.0	255.0	110.0	5.0	4.0	0.0	0.0	527.0
2002	0.0	0.0	0.0	8.0	2.0	26.0	0.0	16.0	35.0	0.0	0.0	4.0	91.0
2003	0.0	17.0	1.5	0.0	0.0	79.5	193.0	57.0	11.0	0.0	0.0	0.0	359.0
2004	0.0	0.0	0.0	0.0	0.0	44.5	31.5	103.5	0.5	2.0	0.0	0.0	182.0
2005	0.0	8.0	0.0	6.0	16.0	35.0	128.0	45.0	45.0	0.0	0.0	0.0	283.0
2006	0.0	0.0	0.0	2.0	0.0	21.0	44.0	137.0	6.0	0.0	0.0	0.0	210.0
2007	0.0	22.0	27.0	7.0	0.0	3.0	59.0	67.0	20.0	0.0	0.0	0.0	205.0
2008	0.0	0.0	0.0	23.5	56.5	181.5	37.2	163.2	14.0	0.0	0.0	0.0	475.9
2009	0.0	0.0	4.0	0.0	10.0	18.0	87.0	36.0	1.0	0.0	0.0	0.0	156.0
2010	0.0	0.0	0.0	11.0	11.0	49.5	122.0	103.0	184.5	0.0	16.0	14.0	511.0
2011	0.0	16.0	0.0	0.0	0.0	0.0	49.0	172.8	76.2	0.0	0.0	0.0	314.0
2012	0.0	0.0	0.0	27.6	5.4	10.0	19.0	278.0	140.0	0.0	0.0	0.0	480.0
2013	31.0	20.0	1.0	0.0	3.0	50.0	130.3	172.0	166.0	2.0	0.0	0.0	575.3
2014	0.0	0.0	0.0	6.0	18.0	9.0	89.0	96.0	139.0	0.0	0.0	0.0	357.0
2015	0.0	0.0	10.5	0.0	14.0	103.0	153.0	87.0	17.0	0.0	0.0	0.0	384.5
2016	0.0	2.0	0.0	0.0	0.0	56.0	82.0	355.0	3.0	42.0	0.0	0.0	540.0
2017	18.0	0.0	23.0	0.0	56.0	78.0	197.0	49.5	32.0	0.0	0.0	0.0	453.5
2018	0.0	0.0	0.0	0.0	3.0	74.5	107.0	79.5	15.0	0.0	0.0	0.0	279.0
2019	1.0	0.0	0.0	0.0	40.5	42.0	203.5	209.0	40.5	4.5	1.0	0.0	542.0

Table 2: analysis of monsoon period rainfall data for Jodhpur

Month year	July	Aug.	Sept.	Total of Monsoon rainfall (x)	Square of x $x^2$
1990	495.0	170.5	96.5	762.0	5,80,644.0
1991	95.5	95.0	08.5	199.0	39,601.0
1992	82.3	172.0	233.0	487.3	2,37,461.3
1993	150.0	06.0	35.0	191.0	36,481.0
1994	149.0	135.0	56.0	340.0	1,15,600.0
1995	283.8	60.0	01.0	344.8	1,18,887.0
1996	89.8	242.6	10.0	342.4	1,17,237.8
1997	61.1	317.4	05.1	383.6	1,47,149.0
1998	36.0	97.5	144.0	277.5	77,006.3
1999	57.0	182.0	11.0	250.0	62,500.0
2000	219.0	32.0	02.0	253.0	64,009.0
2001	255.0	110.0	05.0	370.0	1,36,900.0
2002	0.0	16.0	35.0	51.0	2,601.0
2003	193.0	57.0	11.0	261.0	68,121.0
2004	31.5	103.5	0.5	135.5	18,360.3
2005	128.0	45.0	45.0	218.0	47,524.0
2006	44.0	137.0	06.0	187.0	34,969.0
2007	59.0	67.0	20.0	146.0	21,316.0
2008	37.2	163.2	14.0	214.4	45,967.4
2009	87.0	36.0	01.0	124.0	15,376.0
2010	122.0	103.0	184.5	409.5	1,67,690.3
2011	49.0	172.8	76.2	298.0	88,804.0
2012	19.0	278.0	140.0	437.0	1,90,969.0
2013	130.3	172.0	166.0	468.3	2,19,304.9
2014	89.0	96.0	139.0	324.0	1,04,976.0
2015	153.0	87.0	17.0	257.0	66,049.0
2016	82.0	355.0	03.0	440.0	1,93,600.0
2017	197.0	49.5	32.0	278.5	77,562.25.0
2018	107.0	79.5	15.0	201.5	40,602.3
2019	203.5	209.0	40.5	453.0	2,05,209.0
Total	3,705.0	3,846.5	1,552.8	9,104.3	33,42,477.6

Table 3: analysis of non-monsoon period rainfall data for Jodhpur

Month year	Jan.	Feb.	Mar.	Apr.	May	June	Oct.	Nov	Dec.	Total of Monsoon rainfall (x)	Square of x x <sup>2</sup>
1990	0.0	26.0	0.0	0.0	27.0	0.0	0.0	0.0	0.0	53.0	2,809.0
1991	0.0	0.0	0.0	21.5	0.0	10.0	0.0	0.0	2.0	33.5	1,122.3
1992	21	10.2	2.0	0.0	4.4	1.1	0.0	0.0	0.0	38.7	1,497.7
1993	2.0	0.0	0.0	10.0	6.0	18.0	3.0	2.0	0.0	41.0	1,681.0
1994	24.0	0.0	0.0	18.0	6.0	8.0	0.0	0.0	0.0	56.0	3,136.0
1995	0.0	0.0	0.0	0.0	0.0	16.2	13.0	0.0	0.0	29.2	852.7
1996	0.0	0.0	0.0	6.0	24.3	148.4	0.0	0.0	0.0	178.7	31,933.7
1997	0.0	0.0	0.0	0.0	19.5	79.0	82.0	8.0	0.0	188.5	35,532.3
1998	0.0	0.0	11.0	20.5	0.0	175.0	93.0	0.0	0.0	299.5	89,700.3
1999	5.0	17.0	0.0	0.0	11.5	57.0	17.0	0.0	0.0	107.5	11,556.3
2000	0.0	0.0	0.0	2.0	5.0	13.0	0.0	0.0	0.0	20.0	400.0
2001	0.0	0.0	0.0	5.5	56.5	91.0	4.0	0.0	0.0	157.0	24,649.0
2002	0.0	0.0	0.0	8.0	2.0	26.0	0.0	0.0	4.0	40.0	1,600.0
2003	0.0	17.0	1.5	0.0	0.0	79.5	0.0	0.0	0.0	98.0	9,604.0
2004	0.0	0.0	0.0	0.0	0.0	44.5	2.0	0.0	0.0	46.5	2,162.3
2005	0.0	8.0	0.0	6.0	16.0	35.0	0.0	0.0	0.0	65.0	4,225.0
2006	0.0	0.0	0.0	2.0	0.0	21.0	0.0	0.0	0.0	23.0	529.0
2007	0.0	22.0	27.0	7.0	0.0	3.0	0.0	0.0	0.0	59.0	3,481.0
2008	0.0	0.0	0.0	23.5	56.5	181.5	0.0	0.0	0.0	261.5	68,382.3
2009	0.0	0.0	4.0	0.0	10.0	18.0	0.0	0.0	0.0	32.0	1,024.0
2010	0.0	0.0	0.0	11.0	11.0	49.5	0.0	16.0	14.0	101.5	10,302.3
2011	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	256.0
2012	0.0	0.0	0.0	27.6	5.4	10.0	0.0	0.0	0.0	43.0	1,849.0
2013	31.0	20.0	1.0	0.0	3.0	50.0	2.0	0.0	0.0	107.0	11,449.0
2014	0.0	0.0	0.0	6.0	18.0	9.0	0.0	0.0	0.0	33.0	1,089.0
2015	0.0	0.0	10.5	0.0	14.0	103.0	0.0	0.0	0.0	127.5	16,256.3
2016	0.0	2.0	0.0	0.0	0.0	56.0	42.0	0.0	0.0	100.0	10,000.0
2017	18.0	0.0	23.0	0.0	56.0	78.0	0.0	0.0	0.0	175.0	30,625.0
2018	0.0	0.0	0.0	0.0	3.0	74.5	0.0	0.0	0.0	77.5	6,006.3
2019	1.0	0.0	0.0	0.0	40.5	42.0	4.5	1.0	0.0	89.0	7,921.0
Total	102.0	138.2	80.0	174.6	395.6	1,497.2	262.5	27.0	20.0	2,697.1	3,91,631.3

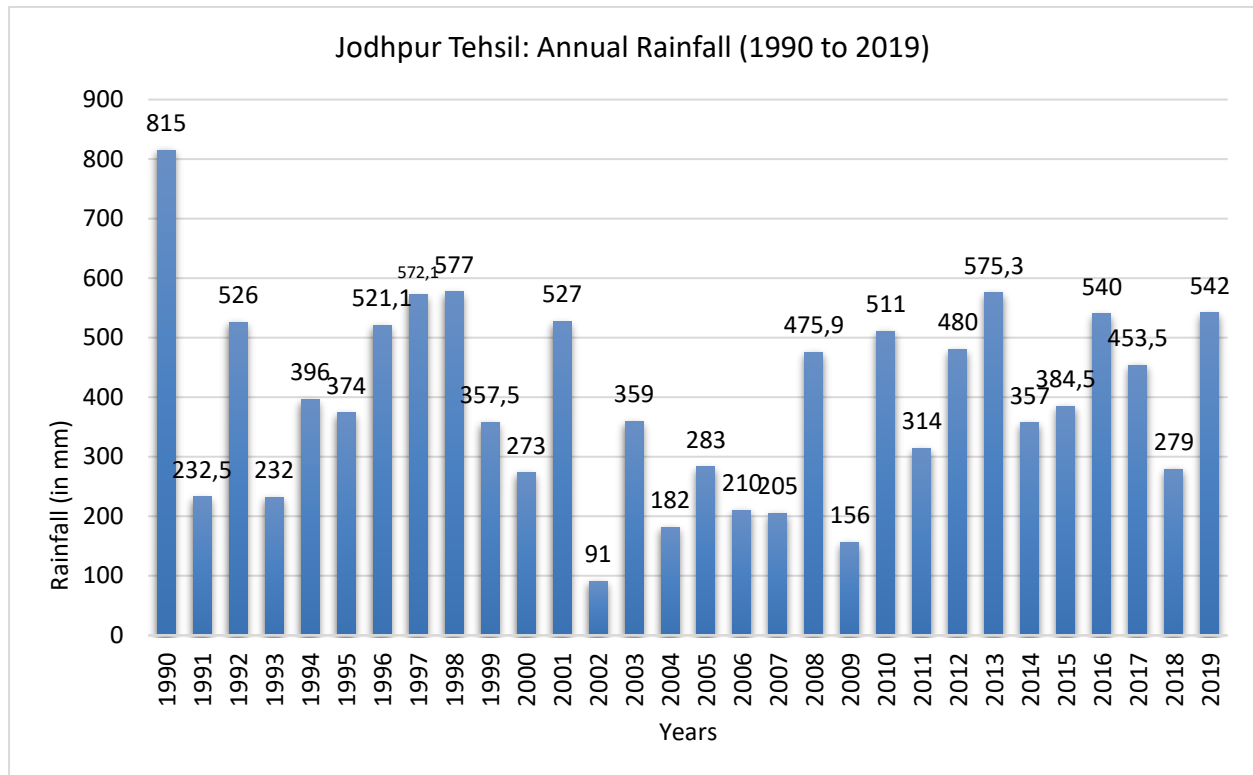


Figure 2: annual rainfall data of Jodhpur Tehsil (1990 to 2019)

The date of onset of the southwest monsoon over Jodhpur tehsil is around 2<sup>nd</sup> July, while the date of its withdrawal is around 19<sup>th</sup> September (Pai D.S. 2020), so July to September is south-west monsoon period in Jodhpur. Table 1 and 2 make it clear that the study region receives most of the share of its annual rainfall during these monsoon months.

Thus, the rainfall in the study region is typical monsoonal-type, as in the rest of India. The months of July and August receive the largest share of the annual rainfall. The analysis shows that the rainfall pattern of the study area follows the monsoonal pattern and this leads to situation of water scarcity in non-monsoon months, as happens in rest of India too (Jain Sharad K. 2012).

#### RAIN FALL VARIABILITY ANALYSIS

Rainfall variability analysis is done on the basis of calculations of Mean, Standard Deviation (table 2 and table 3) and the Coefficient of Variation.

Mean rainfall = Total rainfall in the years under consideration / Number of years

$$\sigma = \sqrt{\{n\sum x^2 - (\sum x)^2\} / n^2}$$

where,  $\sigma$  = Standard Deviation,

n = number of years

x= seasonal rainfall in a particular year

Coefficient of Variation = (Standard Deviation/ Mean) x 100

After the detailed analysis, the average rainfall in the Monsoon Period comes out to be 303.48 mm. The standard deviation of this period comes out to be 138.99 and coefficient of variation is 45.80.

The average rainfall of Non-Monsoon Period is found to be 89.9 mm. Standard deviation of the Non-Monsoon Period comes out to be 70.51 and Coefficient of variation is 78.43.

Average annual rainfall is 393 and Standard deviation comes out to be 159.97. The Coefficient of Variation is 40.71.

## RESULTS AND DISCUSSION

Based on the above data and the detailed analysis, few patterns regarding rainfall in the study area can be observed. Majority of the rainfall is received in the three months of the monsoon season. Even in this period, rainfall is highly concentrated in a few days.

It is found that vast amounts of rainfall is received in a very short period of time, which creates challenges in efficiently collecting and storing it for future use. Also, it creates challenges of waterlogging, especially in Jodhpur city, because its drainage network isn't well-equipped to drain out such large amounts of water rapidly.

The coefficient of variation in monsoon period:

If the Coefficient of Variation is less than 50 %, that means better reliability (Ramana Rao 1988). If the Coefficient of Variation is more than 50 %, that means less reliability, not dependable.

The analysis shows that the coefficient of variation in monsoon period is 45.80, which is less than 50 %, that means better reliability (Ramana Rao 1988).

The coefficient of variation in non-monsoon period:

The coefficient of variation in non-monsoon period is 78.43, which is more than 50 %, that means less reliability. It is not dependable.

Coefficient of Annual Variation:

If the Coefficient of Annual Variation is less than 25 %, that means better reliability (Ramana Rao 1988). If the Coefficient of Annual Variation is more than 25 %, that means lesser reliability and not dependable.

The Coefficient of Annual Variation is 40.71, which is more than 25 %, that means lesser reliability and it is not dependable.

Looking to the above challenges of seasonal and annual variations, a well-planned and executed rainwater harvesting system is needed for Jodhpur. Thus, the Public Health Engineering Department, Jodhpur need to work very seriously for the effective utilization of the very precious water resource received through rainfall.

Furthermore, the rainfall data and the above analysis is a critical step towards ensuring balanced water supply in Jodhpur. It is also essential for better planning and proper designing of storm water network to avoid water logging and design of appropriate, essential rain water harvesting structures in the Suncity, Jodhpur at the earliest.

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