



INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

TRENDS OF RAINFALL AND URBAN WATER SUPPLY IN RAJASTHAN STATE

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Abstract- Present paper examines the rainfall profile of Rajasthan. This largest Indian state is known for extreme temperatures, water scarcity, scanty rains and frequent droughts. It is feared that any significant change in temperature and rainfall properties of the state can aggravate its climatic harshness, and thus, can adversely impact the physical, as well as economic landscapes. The analysis reveals that most of the districts in the state have witnessed a significant warming during last century. The districts of Sikar and Dausa, on the other hand, have recorded a cooling trend. Interestingly, the warming is more prominent in the western part of the state as compared to its eastern part. As for as rainfall is concerned, it has recorded an increase for most of districts, however, the districts lying near Tropic of Cancer have become drier. Drinking Water Security has become a challenge for the Rajasthan, specifically in urban areas. An attempt has been made to assess the status of urban water supply in the state of Rajasthan. The evaluation clearly shows that there is a lot of disparity in the water supply in the cities of Rajasthan. The main reason for this is the depleting groundwater level, erratic and low rainfall and lack of water storage resources. At present, this crisis is increasing due to rapid increase in population, in recent time climate change has aggravated the problem more and depleting water resources. One of the main reasons for this is that the people of Rajasthan are completely dependent on government schemes by abandoning traditional water sources. This shows that education is increasing in Rajasthan, but awareness about water conservation is decreasing. The Rajasthan government has made many changes in many policies and policy making related to water, one of them is drinking water supply. There is always a huge gap between policy and implementation. To improve this, the main task is to change the attitude of the public towards the use of water and emphasize on water conservation.

Index Terms – Rainfall, Urban Water Supply, LPCD, Divisions

1. INTRODUCTION

The state of Rajasthan is located in the northwest of India. The largest province covering an area of 3,42,239 square kilometers, is surrounded by 23 ° 30'North and 30 ° 11'North latitude and 69 ° East and 78 ° East longitude. The state shares a border with the western and northwestern border of Pakistan about 1070 kilometers. Gujarat and part of Madhya Pradesh to the south, the remainder of Madhya Pradesh and Uttar Pradesh to the east and Punjab and Haryana to the north and northeast. Rainfall is a phenomenon, affecting directly or indirectly all sectors such as agriculture, insurance, industry and other related sectors. It is well established that rainfall varies on a global and regional scale due to global warming. Rajasthan contributes 10.4% of India's total area. The landscape of Rajasthan is made up of the Thar desert and the Aravalli Mountains, which run from one end of the horizon to the other (over 850 miles [850 km]). Although a large percentage of the total area is desert with little forest cover. As the population of Rajasthan increases day by day, it is ranked seventh in India. People participate directly or indirectly in various activities such as saving water for continuous use. Rainfall is one of the most important natural factors that determine the stability of the population in the region. Directly or indirectly all people are dependent on rainfall. Water shortage and unequal distribution of water is available in Rajasthan state. According to the Vyas committee report (published in 2009), the annual per person availability in the Rajasthan is less than 800 m³ (but generally required is 1000 M³). The land area of Rajasthan is 10.41 percent (342239 km²) of total area of India's and population of Rajasthan 5.66 % (according to 2011) of India's total population, but Rajasthan surface water resources has only 1.16 percent of the country's total surface water resources. Studies have shown Rajasthan is among area with high climate sensitivity and

lowest adaptive capability. 70 percentages of habitations in the Rajasthan face problems getting potable drinking water. The available water has high fluoride, salinity, nitrates, total dissolved solids (TDS). The canal water supply is the only reliable drinking water sources. in the state about 24.9 % population is urban and 75.1 % population is rural of total population of Rajasthan. Public health engineering department is responsible for mostly urban water supply system water supply. Pressure on urban centers is growing of the state because population Decadal growth rate of urban area is 29%, but this growth rate is high compare to overall Rajasthan population growth rate because Rajasthan population growth rate is 21.31 % (according to 2011). All 222 cities in the urban state have benefited from various drinking water schemes. Out of these, about 28 percent cities are being provided drinking water from surface water sources and 50 percent from ground water sources. The drinking water schemes of the remaining about 22 percent cities are based on mixed water sources of surface and ground water. the gap between water supply is 24 hours to 96 hours. Frequency of water supply in urban areas varies; once in 24 hours for 108 cities, once in 48 hours for 90 cities, once in 72 hours in 13 towns and once in 96 hours in 4 cities. During summer, when the water shortage is at its height, water is often transported to cities in trains and tankers. Only 30 percent or 64 cities got more than 100 liters per capita per day (LPCD) water against the 135 LPCD standards. All the 222 cities/towns in the state have been benefitted by various drinking water schemes. Out of these, drinking water is being provided to about 28 percent cities from surface water sources and 50 percent from ground water sources. The drinking water schemes of the remaining about 22 percent cities are based on mixed water sources of surface and ground water.

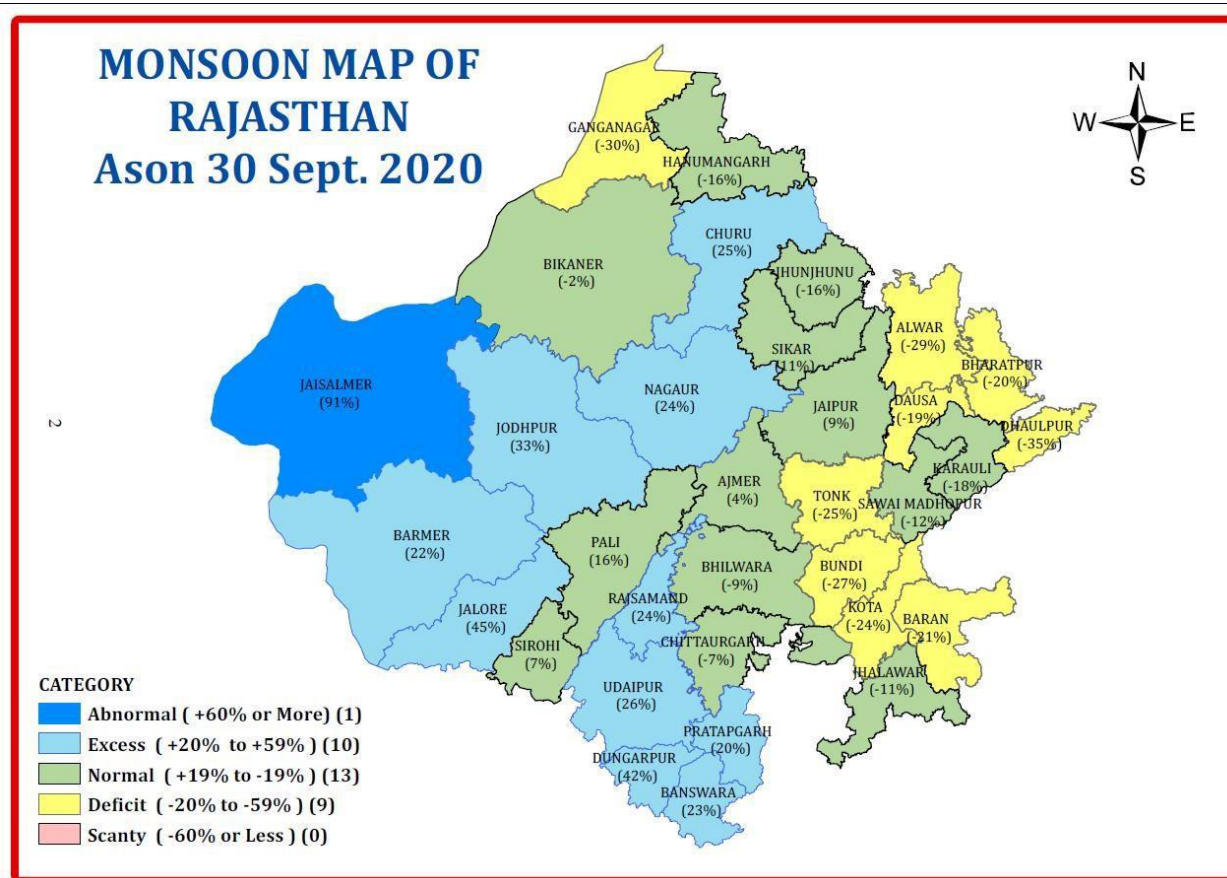


Fig [1]: Monsoon Map of Rajasthan

2. Variation and Distribution in rainfall

Rajasthan receives about 91 percent of its annual rainfall during the Southwest rainfall. Rajasthan receives about 2% share of rainfall during the cold weather season. About 3% during the summer. About 4% during the post monsoon season, of the total annual rainfall respectively. The onset of a southeastern monsoon in the eastern part of the empire is evidenced by the last week of June which hit the entire country in the first week of July. About 34% of the annual rainfall is about one year, and July and August are usually the rainy months. About 1 September the withdrawal of southwestern rainfall begins in the northern and western parts of the state and on 15 September leaves the entire province. During cold weather a small amount of rain i.e. 1cm and 0.7 cm in East and West Rajasthan was adopted. During the southwestern rainy season from June to September the state receives about 90 percent of the total rainfall. The cold weather (January and February) receives a portion of the remaining rainfall that occurs in conjunction with the local transfer function. There is a wide variation in annual rainfall over Rajasthan as the extreme western parts of the Jaisalmer region receive less than 100mm of rain compared to more than 900mm in the eastern parts of Jhalawar and Banswara. East Rajasthan regions receive more rainfall than West Rajasthan. The average annual rainfall in East and West Rajasthan is about 64.9 cm and 32.7 cm respectively. Most of the rainfall in the province is found in the

southern or southeastern districts of the state. To the west the Aravalli hills in the Pali and Jalore regions receive the highest rainfall of 50 cm and 43 cm in West Rajasthan. In the northern or northern and western regions the Jaisalmer region receives the lowest rainfall. Bikaner, Ganganagar, Jaisalmer receive annual rainfall of 26cm, 24cm and 17cm respectively. According to India's Department of Environmental Affairs, rainfall patterns show that during the 2020 rainy season, the onset of the rain was delayed by nine days. The most common date for a hurricane in the province is 15th June, but it arrived on 24 June. It covers the entire empire until the first week of July, 2020. The actual rainfall for the period 1 June to 30 September, 2020 in the province was 520.79 mm, compared to the average rainfall of 520.98 mm, which is 0.04 percent below normal rainfall. In Rajasthan, during the whole of the 2020 monsoon season, there have been abnormal, excess or normal rains in most of the district, where as in Alwar, Bharatpur, Bundi, Dausa, Dholpur, Ganganagar, Kota and Tonk districts, deficit rainfall has been recorded. Many studies are available on the observed trends and variability of rainfall and also extreme rainfall events, but all the studies are based on past 100 years or more data and also the recent years are not included (Guhathakurta et al, 2015; Guhathakurta et al, 2011; Guhathakurta & Rajeevan, 2008 etc). In the present report all the analysis of observed rainfall patterns, trends and variability have been done based on recent past 30 years (1989-2018) that will help to have idea of the recent changes for climate change adaptation and management by the state authorities.

3. Data and Methodology

Daily Rainfall data from 2000 to 2020 is considered for analysis of trend variability and mean rainfall patterns. From the daily rainfall data monthly rainfall series of each station are computed and then monthly district rainfall series has been constructed by considering arithmetic average of all the station rainfall values within the district. The monthly rainfall series of the state has been computed by using area weighted rainfall values of all the districts within the state. The analysis has been done in two parts. For identification of the spatial pattern mean rainfall and variability and observed trends we have used district rainfall series and results have been brought out for four southwest monsoon months viz. June, July, August, September, for the southwest monsoon season and also for annual. For identification of mean pattern and trends of intensities of various rainfall events we used the station daily rainfall data. From mean and standard deviation (SD), the coefficient of variation (CV) is calculated as follows:

$$\text{Coefficient of variation} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

4. Study area

Rajasthan state is situated between 23° 30' – 30° 11' N and 69° 29' - 78° 17' E at the northwestern region of India, covering a widespread area of 3, 42,239 km² (10.4% of the country). As per details from Census 2011, it has population of about 68 million and 75 % of this population resides in rural areas and directly dependent upon rainfall availabilities for agriculture and other use. This study includes 19853278 urban population, which is 24 percent of the total population of Rajasthan. (According to 2021 population prediction). Four regions can be clearly demarcated in the state, desert in west with barren hills, rocky/sandy plains in north east, the Aravalli hills in the center, extending from north to south, and south eastern plateau. Low and erratic rainfall in the state characterizes it as one of the driest states in India, it receives about 574 mm average annual rainfall which deviates from as low as 100 mm in Jaisalmer (Lowest in the state) to 550 mm in Ajmer and highest (1638 mm) in Mount Abu (Sirohi district) situated on southeast region of the state. The whole state was considered as the study area taking 31 stations as data collection points, well spread over the state, covering all the districts and for urban water supply 214 cities included in this study.

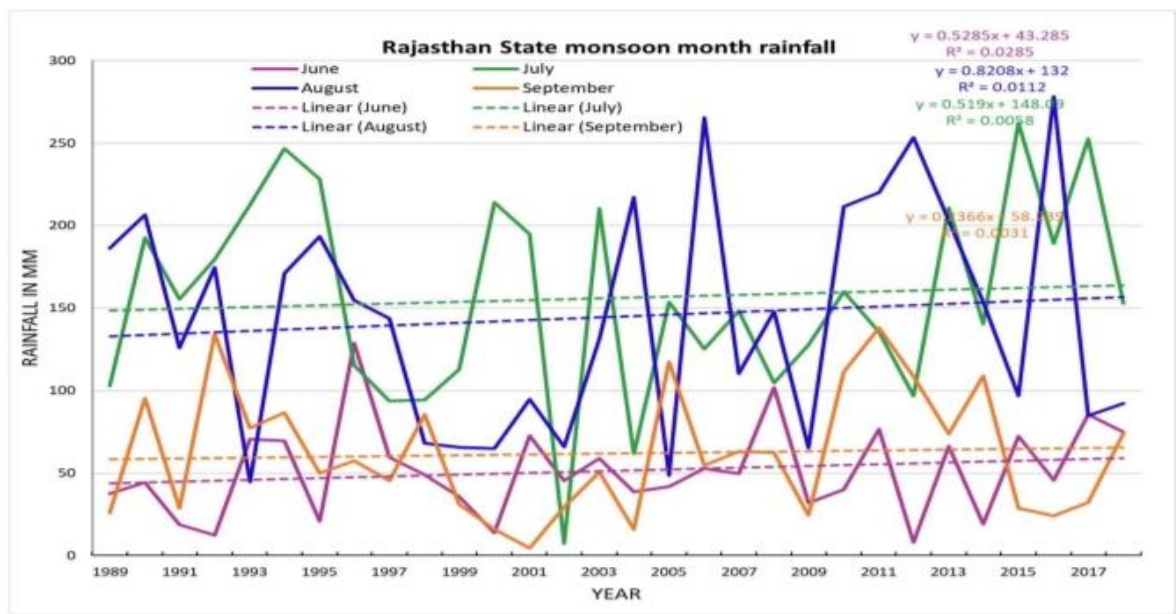


Fig [3]: Time series of rainfall in mm for the southwest monsoon season and annual trends

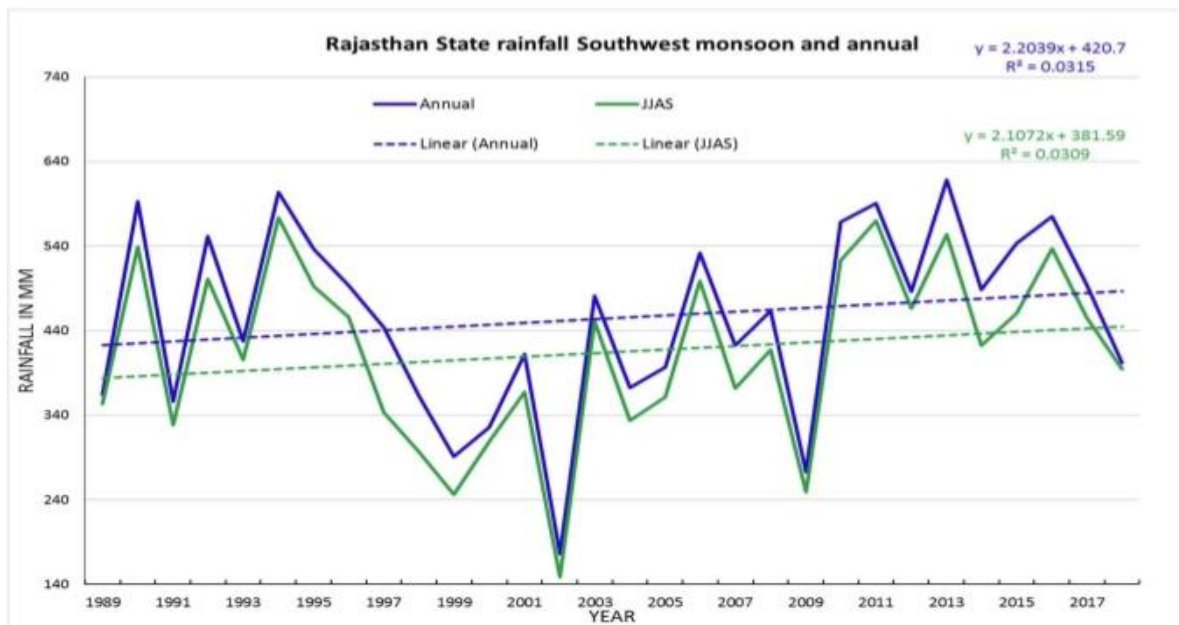


Fig [4]: Time series of rainfall in mm for the months of June, July, August, September and trends

4.2 Water Supply Situation In Rajasthan Cities: - The water supply data collection of these 214 cities of Rajasthan shows that there is wide variation in water supply in each city of Rajasthan. Out of 214 cities, only 3.14% cities have water supply more than 135 and only 18.7% cities have water supply more than 100 LPCD.

(LPCD)	No. of towns	% of total towns
Below 40	5	2.33
40-60	33	15.42
61-80	88	41.12
81-100	48	22.43
101-135	32	14.95
Above 135	8	3.74
Total	214	100

Table [2]: Relationship between supply and towns

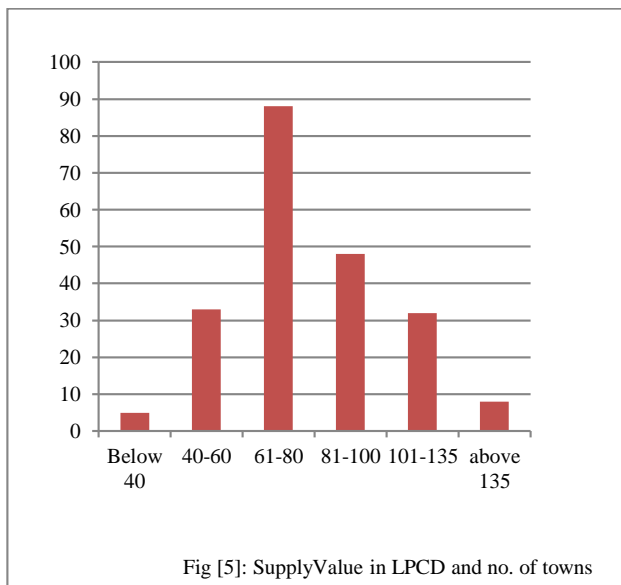


Fig [5]: SupplyValue in LPCD and no. of towns

4.3. Water Supply Interval: - The interval of urban water supply in Rajasthan varies from 24 hours to 96 hours. Out of 214 cities, only about 50% of the cities are supplied with water every day. Higher water supply intervals have been observed at maximum in small cities, and when there is a reduction or delay in rainfall, this interval is even greater.

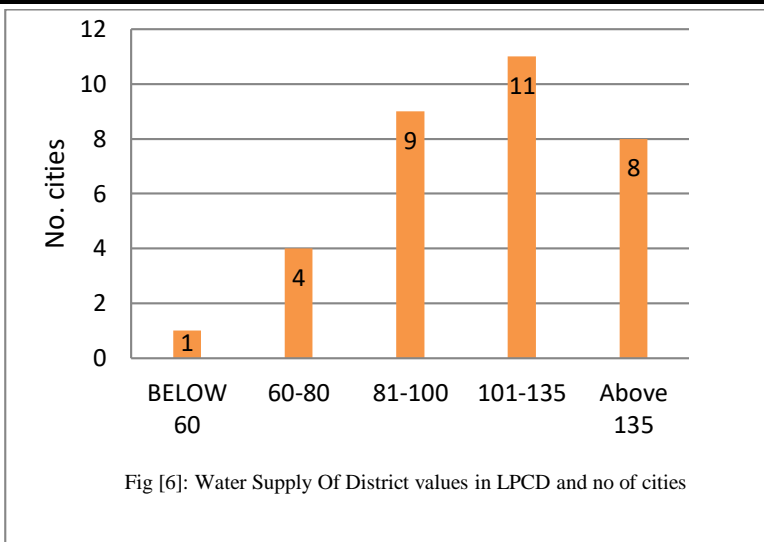
Water Supply Interval in hours	No. of towns
24	108
48	89
72	13
96	4
Total	214

Table [3]: Relationship between supply and towns

4.4. Water Supply Situation in Rajasthan District: - According to the district water consumption, the lowest water supply is being done in Dausa (in LPCD) district, which is only one-fourth of Kota district. The main reason for this is the inadequacy of surface water sources, even if it is a part of the eastern state and the environmental conditions are better than in west Rajasthan. On the other hand, look at Jaisalmer, which is the district with the most extreme conditions in Rajasthan, where the water supply is 155 LPCD, because of there is a permanent project like IGNP.

(LPCD) Supply	% of total district
Below 60	3
60-80	12.12
81-100	27.27
101-135	33.33
Above 135	24.24
Total	100

Table [4]: Relationship between supply and districts

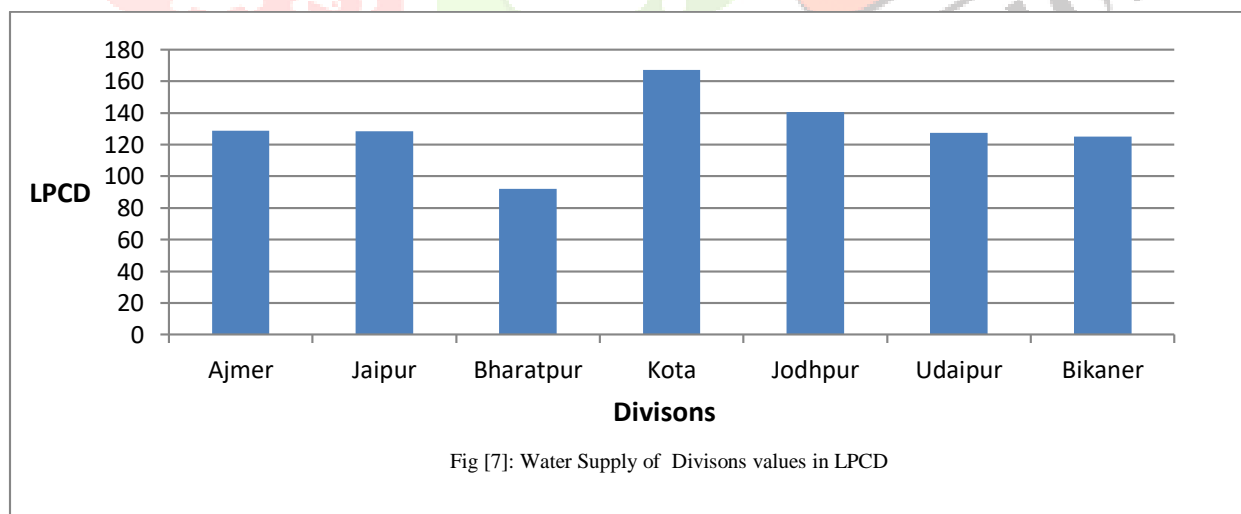


4.5. Water Consumption of All Division of Rajasthan

According to the study, it is found that out of the 7 divisions, the lowest average water supply is 92 LPCD in Bharatpur, which is located in the eastern part of Rajasthan. Where the ground water and average rainfall is higher than the west division, but it is far behind the western division and other divisions in water supply. The main reason for this is the absence of any major drinking water project in the entire Bharatpur division.

S.N.	DIVISION	POPULATION	MLD	LPCD
1	Ajmer	2788120	359.5	128.94
2	Jaipur	6241395	802.34	128.55
3	Bharatpur	1370300	126.33	92.2
4	Kota	2546021	425.7	167.2
5	Jodhpur	2956086	415.03	140.4
6	Udaipur	1457234	185.64	127.39
7	Bikaner	2623122	328.41	125.2

Table [5]: Data of Divisional water supply and population



4.6. Comparison Between Last 6 Years Water Supply Data: - PHED's last 6 years data shows that the average urban water supply has increased by 10 LPCD from 2015-16 to 2021. The urban population has increased by 10.76% between 2016 and 2021. But there has been an increase of 20.2% in the total MLD, which is good from the point of view of water supply. But still the water supply quantity mainly depends on the amount of rainfall, because the urban area of Rajasthan mainly depends on the surface water sources, where the water comes from the rainfall.

Years	Population	MLD	LPCD
2015-16	17923796	2198.03	122.74
2016-17	18040399	2268.4	125.74
2017-18	18597711	2341.12	125.8
2018-19	18877219	2269.58	120.23
2019-20	19235519	2289.17	119
2020-21	19853278	2642.95	133.125

Table [6]: Annual water supply and population

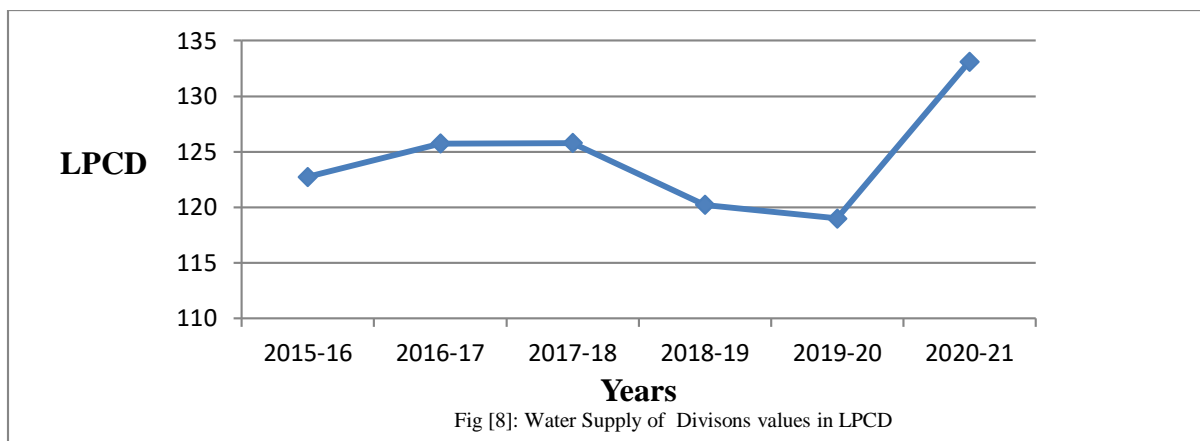


Fig [8]: Water Supply of Divisions values in LPCD

4.7. Water Sources Contribution in Urban Water Supply: - All the 222 cities/towns in the state have been benefitted by various drinking water schemes. Out of these, drinking water is being provided to about 28 percent cities from surface water sources and 50 percent from ground water sources. The drinking water schemes of the remaining about 22 percent cities are based on mixed water sources of surface and ground water.

S.N.	Water Sources	Total Water Supply In MLD	% of total urban water supply
1.	Bisalpur dam	830	31
2.	IGNP-canal	660.92	25
3.	Chambal river	523.9	20
4.	Lacks	118	5
5.	Jawai dam	58.2	2
6.	Other Sources	451.93	17
	Total	2642.95	100

Table [7]: Total water supply[in MLD] and % of total urban water supply

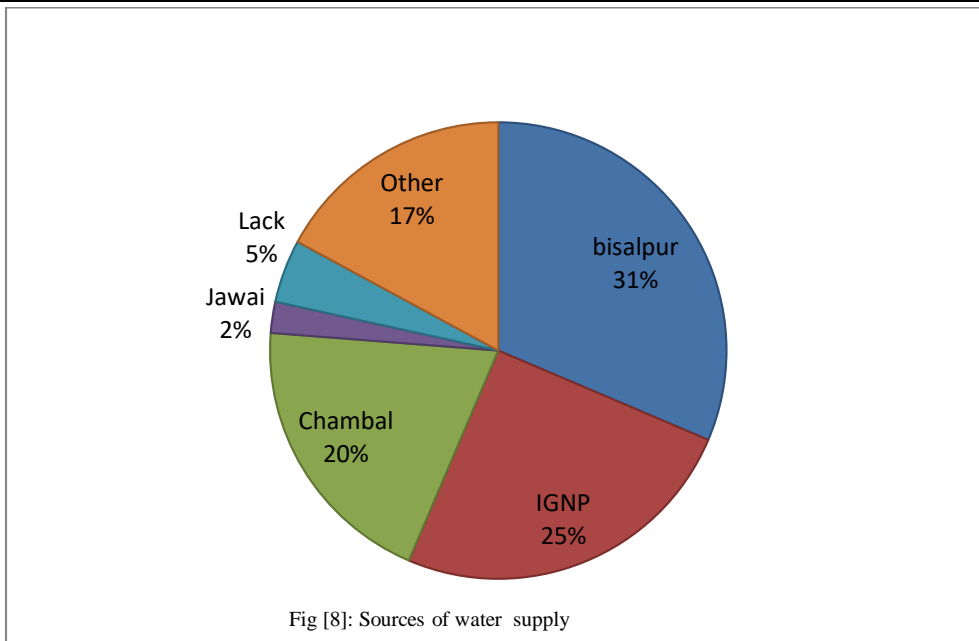


Fig [8]: Sources of water supply

4.8 District rainfall mean, variability and trend:

Mean and coefficient of variation: - Table gives the rainfall statistics for the districts of Rajasthan for the four monsoon months, southwest monsoon season and annual while Fig. 4 to 5 shows the spatial pattern of these statistics. It can be seen that south-eastern districts viz. Pratapgarh, Banswara, Jhalawar, and Sirohi receive highest rainfall over other districts during all the months and season. Rainfall receives over these districts are around 85-100 mm in June, 280-335mm in July, 265-320mm in August, 120-140mm in September, 720- 880mm in SW monsoon and 780-920mm in annual. Lowest rainfall receives during the SW monsoon season(169.9mm) as well as annual (208.5m) is over Sri Ganganagar district of northern Rajasthan.

DISTRICT	JUNE		JULY		AUGUST		SEPTEMBER		MONSOON		ANNUAL	
	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV	MEAN	CV
AJMER	48.3	74	158.8	44	165.5	55	64.4	82	437.0	31	472.4	30
ALWAR	71.6	110	172.4	51	191.7	59	98.4	77	534.1	39	602.0	36
BANSWARA	90.8	65	320.0	41	296.2	65	142.3	63	849.2	36	879.9	34
BARMER	31.9	97	111.6	88	102.3	102	46.1	110	291.8	54	315.5	50
BHARATPUR	62.1	94	179.7	47	185.8	53	97.9	68	525.5	31	577.5	27
BHILWARA	59.6	64	221.4	40	215.4	61	72.1	66	568.5	29	597.2	28
BIKANER	41.6	83	87.7	59	68.4	65	31.5	95	229.3	35	286.3	32
BUNDI	69.0	73	226.5	49	229.6	46	83.5	66	608.6	23	638.3	22
CHITTORGARH	67.6	67	270.7	37	264.1	63	93.9	63	696.3	29	725.2	28
CHURU	54.2	70	118.1	50	93.8	64	45.8	84	312.0	38	378.0	35
DUNGARPUR	80.8	69	265.7	44	234.6	68	111.5	75	692.6	37	717.9	56
GANGANAGAR	29.7	90	57.7	71	46.4	92	36.1	118	169.9	54	208.5	49
JAIPUR	60.5	77	168.3	40	171.5	63	72.8	67	473.1	31	524.3	28
JAISALMER	28.2	106	65.0	83	62.0	87	26.9	127	182.1	43	210.9	39
JALORE	38.1	91	190.5	88	125.0	94	67.5	118	421.1	56	446.6	53
JHALAWAR	99.7	83	312.4	46	298.9	49	120.1	63	831.1	28	879.5	28
JHUNJHUNU	68.3	92	136.9	52	132.7	61	59.3	80	397.3	37	470.9	32
JODHPUR	36.4	92	107.8	59	98.6	62	42.2	109	285.0	35	312.4	35
KOTAH	77.6	96	239.2	53	241.4	52	80.7	67	638.9	36	673.7	35
NAGOUR	52.5	103	125.5	45	121.0	181	44.2	70	343.1	78	384.4	72
PALI	40.4	81	184.3	70	163.9	78	57.4	101	446.1	51	464.5	51
SAWAI MADHOPUR	61.6	87	207.3	52	222.4	58	81.8	78	573.1	36	614.1	33
SIKAR	62.9	89	143.1	49	133.3	73	50.3	85	389.6	39	447.0	36
SIROHI	54.3	80	333.6	92	221.4	88	112.2	122	721.6	62	746.4	61
TONK	45.1	433	183.8	226	197.7	125	64.2	510	490.8	106	525.4	115
UDAIPUR	63.2	61	240.1	48	198.9	67	99.0	74	601.1	36	624.9	34
DHOLPUR	57.0	108	186.7	47	209.8	51	102.4	68	555.9	32	611.1	30
BARAN	99.7	119	307.8	48	287.8	50	108.7	71	804.0	34	847.0	32
DAUSA	61.3	85	201.0	49	206.4	68	96.2	218	564.9	65	609.6	77
RAJASMAND	57.6	56	203.4	47	188.5	53	82.5	79	532.0	28	566.8	27
HANUMANGARH	46.9	71	82.7	61	60.6	80	41.3	93	231.6	33	286.1	116
KARALI	64.2	316	173.9	135	204.3	126	77.9	265	520.3	70	565.8	67
PRATAPGARH	95.7	73	331.8	38	318.9	60	133.7	54	880.2	30	918.8	28

Table [8]: Seasonal and annual Rainfall mean and coefficient of variation values across all districts of Rajasthan

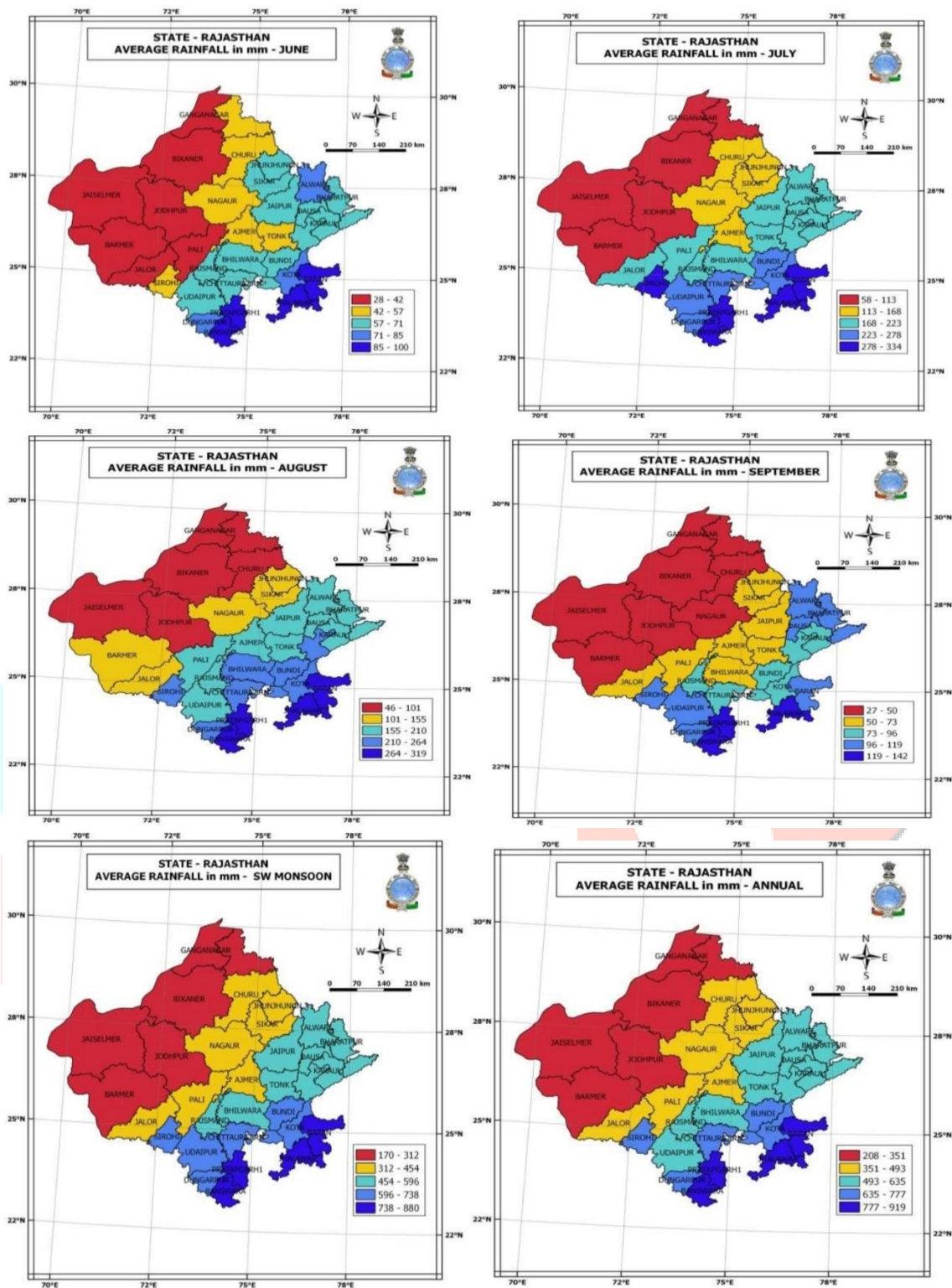


Fig [9]: Mean Rainfall Pattern over districts of Rajasthan

4.9 Trend in district rainfall:

Figure shows the trends in district rainfall. It can be seen that June rainfall has shown a significant increasing trend over Sawai Madhopur district and insignificant increasing trend in most of the districts except for Barmer, Sikar, Banswara, Prathapgarh which showed a non-significant decreasing trend. For the July month only, significant trend has been noticed in Hanumangarh district (significant decreasing trend). No districts of entire Rajasthan have shown any significant trend in August rainfall while September rainfall of Sri Ganganagar district of northern Rajasthan has shown a significant increasing trend. None of the districts of entire Rajasthan state showed any significant trend in the southwest monsoon season rainfall as well as in the annual rainfall.

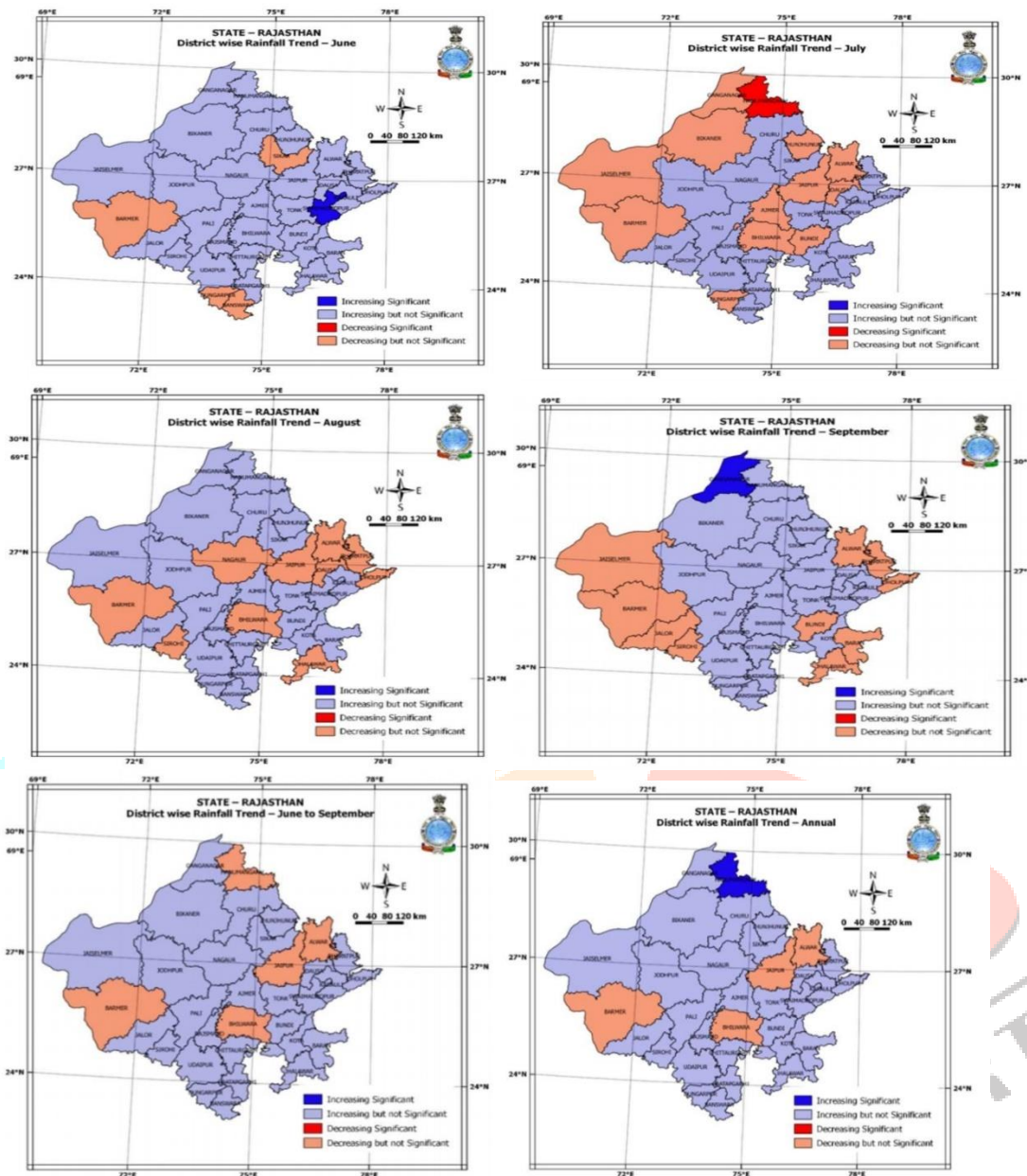


Fig [10]: Trends in district Rainfall

5.Data Analysis

Rainfall Deviation (R_{fdev}) is expressed in % terms of difference and expressed as below

$$R_{fdev} = \frac{R_{fn} - R_{fi}}{R_{fi}}$$

Where, R_{fi} = current rainfall for a comparable period (in mm)

R_{fn} = the normal rainfall (at least 30 years average) for the same period (in mm).

The IMD classification of rainfall deviation is given in table:

Deviation from Normal Rainfall (%)	Category
+60% or More	Abnormal
+20% to +59%	Excess
+19 to -19	Normal
-20 to -59	Deficient
-60 to -99	Large Deficient
-100	No Rain

Table [9]: Category and rainfall deviation

5.1. Analysis of Average Rainfall events of different intensities:

The Monthly deviation of Rainfall (%) is calculated for Rajasthan for June, July, August, September, June to September. Graph shows that the maximum rainfall lies in the month of august is 144.40% which is very large as compare to normal rainfall. In the month of July the minimum Rainfall is 57.50% which is very less as compare to normal rainfall. A slight difference observed in June and September compared to normal rainfall.

5.2. Division Wise Rainfall Analysis:

The maximum average rainfall observed in Udaipur division which is 827.98 mm. Dungarpur, Banswara, Pratapgarh received highest rainfall. The minimum average rainfall observed in Kota division. Overall whole Rajasthan received actual rainfall received is 520.77 mm which is slightly different from normal rainfall 520.98 mm. Station received highest and lowest rainfall during the monsoon is given in the table below:

Divisional Rainfall “ Actual & Normal” (average basis) from June 1st to September 30th 2020

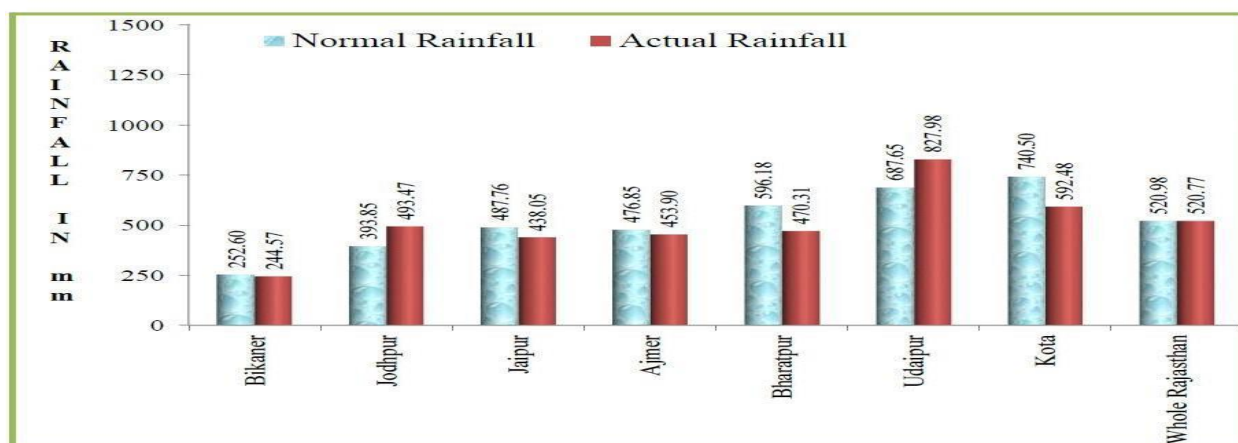


Fig [11]: Highest and Lowest Rainfall During the Monsoon

**Monthly Deviation of Rainfall in (%)
from June 1st to September 30th 2020**

Graph-2

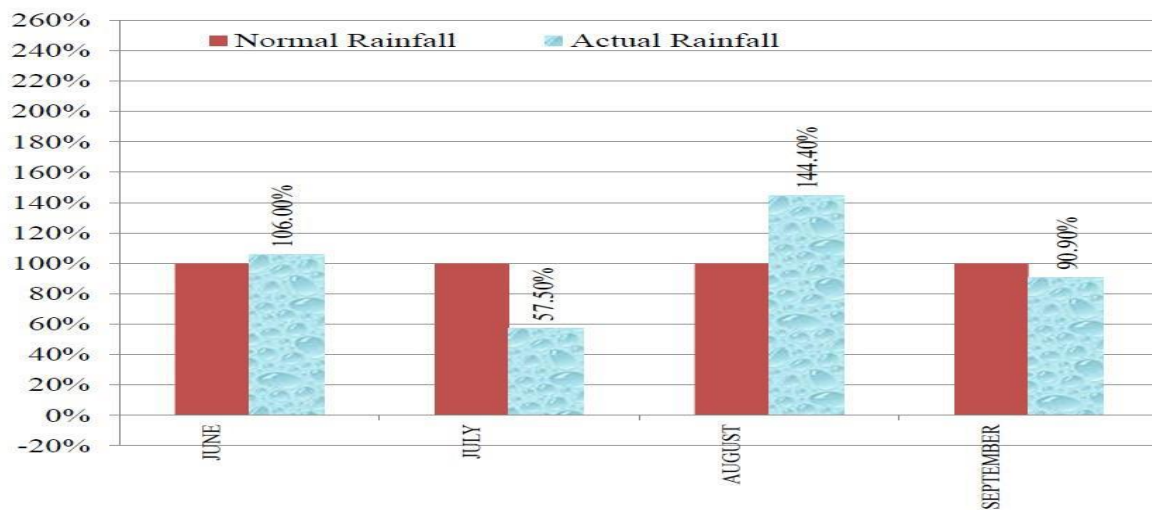


Fig [12]: Highest and Lowest Rainfall During the Monsoon

6. RESULT

The following tables are showing the highest and lowest receiving cities of rainfall.

S.No.	District	Rainfall Station	Normal Rainfall (mm)	Actual Rainfall (mm)
1	Sirohi	Mount Abu	839.0	1753.6
2	Dungarpur	Nithauwa	624.6	1377.0
3	Banswara	Bhungra	844.6	1362.0
4	Dungarpur	Sable	624.6	133.0
5	Partapgarh	Pipalkhunt	864.1	1276.0
6	Banswara	Loharla	844.6	1261.0
7	Banswara	Jagpura	844.6	1252.0
8	Banswara	Ghatol	844.6	1233.0
9	Banswara	Kushaigarh	844.6	1213.0
10	Partapgarh	Arnod	864.1	1198.0

Table [10]: Cities receiving highest rainfall

S.No.	District	Rainfall Station	Normal Rainfall (mm)	Actual Rainfall (mm)
1	Ganganagar	Rawla	201.8	23.0
2	Ganganagar	Gharsana	201.8	54.0
3	Tonk	Nagar fort	557.0	65.0
4	Bikanar	Lunkaransar	229.6	96.0
5	Hanumangarh	Hanumangarh	263.5	103.0
6	Bikanar	Khajwala	229.6	105.0
7	Ganganagar	Sadulsahar	201.8	120.0
8	Ganganagar	Sri Bijainagar	201.8	124.5
9	Ganganagar	Raisinghnagar	201.8	126.6
10	Ganganagar	Karanpur	201.8	127.0

Table [11]: Cities receiving lowest rainfall

Rajasthan gets maximum rainfall in July (38% of SW monsoon rainfall) followed by August (35% of SW monsoon rainfall). 92% of annual rainfall receives during southwest monsoon rainfall (June –September). There is a significant increasing trend observed over Sawai Madhopur district in month of June and over Sri Ganganagar district in the month of September. Hanumangarh district of northern Rajasthan showed a significant decreasing trend in rainfall for the month of July. Remaining districts showed no significant trends in monthly rainfall. During the SW monsoon season, districts in south-eastern Rajasthan received maximum rainfalls (580-860mm) while the north-western parts of the state receive lowest rainfall (170-312mm). Sri Ganganagar is the district which receives lowest rainfall of 169.9mm. During the year maximum rainfall receives over the districts in south-eastern Rajasthan (625 -920mm) while the north-western parts receive lowest annual rainfall of 200-350mm. None of the districts showed any

significant trend in the SW monsoon rainfall as well as in the annual rainfall. South-eastern Rajasthan receive on an average 26 to 34 rainy days (daily rainfall ≥ 2.5 mm) out of 122 days of SW monsoon season while northern Rajasthan gets 15 to 19 rainy days and central parts of Rajasthan get around 20-25 rainy days. For heavy to extremely heavy rainfall (daily rainfall ≥ 6.5 mm) districts of South-eastern Rajasthan and some parts of west Rajasthan get 1.8 to 3 days during the SW monsoon season, northern and central parts of the state get around 0.7 to 1.5 heavy to extremely heavy rainfall days. Number of dry days is maximum over the northern parts of the state (91 to 101 dry days out of 122 days) during the SW monsoon season while on an average 315 to 332 dry days in 365 days have been observed in many parts of western, northern and central districts of Rajasthan. During the period June to September there is a significant increase in Rainy days in stations in Sri Ganganagar, Bikaner, Jodhpur, Udaipur, Chittorgarh, Ajmer, Bundi, Jhalawar and Baran districts. Whereas there is a significant decrease in Rainy days in stations Banswara, Bhilwara and Jaipur districts. While remaining districts did not show any significant change. During the entire year there is a significant increase in Rainy days in many stations of Sri Ganganagar, Ajmer, Chittorgarh and Bundi districts and some stations of Bikaner, Jodhpur, Rajasmand and Udaipur districts. Whereas there is a significant decrease in Rainy days in some stations of Banswara, Bhilwara, Jaipur and Baran districts. During June to September there is a significant increase in dry days in some stations of Udaipur, Jaipur and Kota districts. Whereas there is a significant decrease in dry days in many stations of Sri Ganganagar, Hanumangarh, Bhilwara, Rajasmand, Jodhpur and Ajmer districts. While remaining districts did not show any significant change.

6. CONCLUSION

Low rainfall and high temperature are the most visible characteristics of the desert climate. Despite harsh conditions, it is interesting to note that West Rajasthan is the most densely populated region in the world with a population density of 114 persons/km². Also, as compared to other desert regions of the world, West Rajasthan desert in India receives considerable amount of rainwater. There is a long-felt realization that if we could reclaim this desert and make it more suitable for water availability for agriculture then there would be economic benefits for all concerned. An attractive feature of this paper is that it provides interesting information on climate and rainwater resources in West Rajasthan that is useful for sustainable availability of water and the alleviation of water scarcity. As the average water supply of urban area of Rajasthan as per 2020-21 is 133.12 LPCD which is only slightly less than the standard value of 135 LPCD. But if we look at the specific city. There is a lot of variations in Rajasthan urban water supply. For example - out of 214 cities, only 8 big cities (Ajmer, Bhilwara, Bharatpur, Kota, Jodhpur, Jaisalmer Udaipur, Kankroli) are getting water supply more than 135 LPCD and there are five cities (Kherli, Raigarh, Bandikui, Baswa, Bagru) where water supply is less than 40 LPCD. even though the average urban water supply of Rajasthan is very close to the standard value, but according to a particular city, Rajasthan is very backward in water supply because on the one hand where water supply in Kota city is 225 LPCD, and on the other hand in Bagru (jaipur) only 12 LPCD. About 76.23 per cent of the urban water supply in Rajasthan is dependent on only three projects (Bisalpur dam, IGNP-canal, Chambal river project). And the water supply condition of the cities located in the command area of these projects is better than the rest of the cities.

In the present study we have investigated the rainfall pattern and its variability and also changes based on recent 30 years data. In the analysis we have considered monsoon months, the monsoon season and annual scale. The spatial scale has been considered from state to district for study of rainfall total and stations are being considered for seeing intensities of rainfall. The analysis brought many significant features of rainfall pattern and can be used for water agricultural managements

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