Rainfall trend analysis of three rain gauge stations of Sabarmati river basin, India

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Abstract: Rainfall variations are a common scenario everywhere around the globe. Especially in India the rainfall distribution is heterogeneous in nature. The rainfall trend and pattern change every year in each part of the country. The rainfall depends on the land uses and land cover distribution of the catchment area. The anthropogenic activities are also responsible for the change in rainfall trends over the decades. The main objective of the paper is to compare the rainfall distribution of three rain gauge stations namely Derol, Jotasan and Kheroj respectively of Sabarmati river basin. And to detect the trend analysis of rainfall pattern of three rain gauge stations. And also to identify maximum and minimum years, months of rainfall and number of rainy days in three gauge stations. Environmental conservation should be given more priority than other anthropogenic activities.

***IndexTerms* – Rainfall, trend analysis, annual rainfall, anthropogenic activities, environment.**

I. INTRODUCTION:

India is a country of distributed rainfall which is always changing its precipitation patterns due to changes in recent climatic conditions. Rainfall distribution in India is heterogeneous in nature over the decades. The anthropogenic activities of human beings are the main cause of these drastic changes in our environment. Now days the rain fall pattern and distributions is continuously changing with every passing year around the world. As well as the rainfall intensities are also increased dramatically in the world.

Increasing rainfall intensities and decreasing number of rainy days indicate that the country should urgently initiate adequate measures for extreme events in water sector [1]. Number of rainy days is falling across the basins and rainfall intensities are seen to be increasing. During the concurrent period annual peak rainfall is seem to decrease in the upstream area whereas in the plain areas of the basins show increasing annual peak rainfall. River regulation through storage reservoirs in the past 50 years has resulted in the reduction of peak flows [1].

Analyses of seasonal precipitation showed that the consistent increase in annual precipitation does not come from the summer monsoon period, but rather from an increase in precipitation in the autumn and spring months promoted by a strengthened low pressure [2]. Major part of the total annual precipitation is received during three months July, August and September only. Number of rainy days and maximum daily rainfall also varies in a high range. The distribution of the rainfall is highly non-uniform [3].

Rainfall-runoff affected by fluctuations every year through the annual rainfall showing a rising trend whereas runoff showing a falling trend. The mean annual rainfall and average annual temperature data series in rainfall and non-significant increase in the temperature where mean annual runoff data series shows falling trends. The flora, fauna, ecosystem and human being in this area are always vulnerable to these types of disasters [4]. The result revealed intra- and inter annual variability of rainfall while drought severity index value proved the increasing trend of the number of drought years. The agricultural sectors have to take the declining and erratic nature of rainfall and increasing trend of temperature into consideration [5].

Analysis of monthly trends in precipitation shows negative trend for the months of July, August, September and October in all the rain gauge stations. Months of June shows rising trend and month of January-February recorded decreasing trend [6]. Rainfall-runoff variability is strong in the coastal basins at seasonal and inter-annual time scales and related to extreme EI-Nino events [7]. From the trend analysis of precipitation data it can be concluded that even though insignificant change in the precipitation pattern exists over the last few decades in most parts of the region, there is evidence of some change in precipitation trends in some monsoon months [6].

The rain onsets late and ends up very early which makes the cropping calendar being shorter than before. Late onset, early cessation and prolonged dry spell periods are becoming common which adversely affect the agricultural system. It was also found that very low values of rainfall anomaly which corresponds to severe drought periods had been linked with ENSO events where they coincide or follow the episode shortly [5]. Annual and monsoon rainfall is decreased in the basin around the world. Global climate shift or weakening global monsoon circulation, reduction in forest cover and increasing aerosol due to anthropogenic activities may be the probable of change in rainfall. Anthropogenic activities have lead to increased pollution of the soil all over the world [8].

II. OBJECTIVES OF THE STUDY:

The main objective of the paper is to compare the rainfall data of 30 years of three rain gauge stations of Sabarmati river basin. And to detect the trend analysis of rainfall pattern of three gauge stations namely Derol, Jotasan and Kheroj. The paper also focuses on to identify maximum and minimum years of rainfall in three gauge stations. The main focus is on the rainfall intensities and number of rainy days in three rain gauge stations.

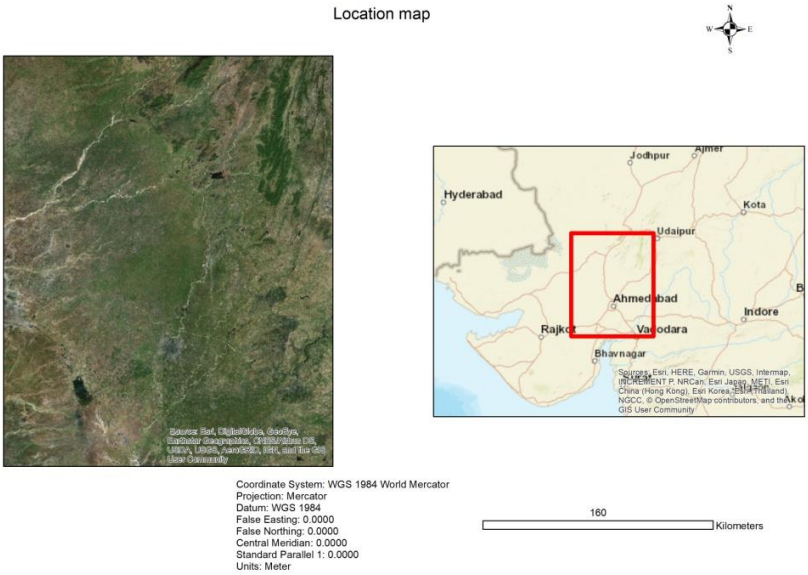
III. METHODOLOGY

The methodology consists of the following steps: 1) first to obtain 30 years rainfall data from Central water commission (CWC) Gandhinagar and missing rainfall data from NASA Agro Climate data website of three rain gauge stations Derol, Jotasan and Kheroj respectively. 2) Then compare the rainfall data of three rain gauge stations. 3) Then analyze these rainfall data. 4) Then identify the maximum and minimum rainfall years and months in all the three gauge stations. 5) After that identify number of maximum rainfall days at each rain gauge stations. 6) Finally based on the critical study some solutions were recommended to preserve our natural environment.

IV. STUDY AREA

The Sabarmati basin extends from Rajasthan and Gujarat having an area of 21,674 Sq.km. It lies between 70°58' to 73°51' east longitudes and 22°15' to 24°47' north latitudes. The study basin is bounded by Aravalli hills on the north and north-east, by Rann of Kutch on the west and by Gulf of Khambhat on the south. The basin is having a main river namely the Sabarmati River which originates from Aravalli hills at an elevation of 762 m near village Tepur, in Udaipur district of Rajasthan. The total length of river from origin to outfall into the Arabian Sea is 371 km and its tributaries are the Wakal, the Hathmati, the Vatrak and the Sei. The major part of basin is covered under agricultural land and water bodies of the total area. The watershed has a major Dharoi dam project and many minor projects such as Guhai dam, Hathimati dam and Harnav dam.

Map 1: Location map of Sabarmati river basin under study



V. DATA COLLECTION AND ANALYSIS

For the study purpose three rain gauge stations are considered. Out of these three rain gauge stations, Jotasan and Kheroj rain gauge stations are situated at the upstream of the Dharoi reservoir and the Derol rain gauge station is located at the downstream of the reservoir. For the study the rainfall data of 30 years (1990 to 2019) of three rain gauge stations is collected from Central water commission (CWC) Gandhinagar and missing rainfall data from NASA Agro Climate data website. These data are then analyzed and compared in Microsoft excel software.

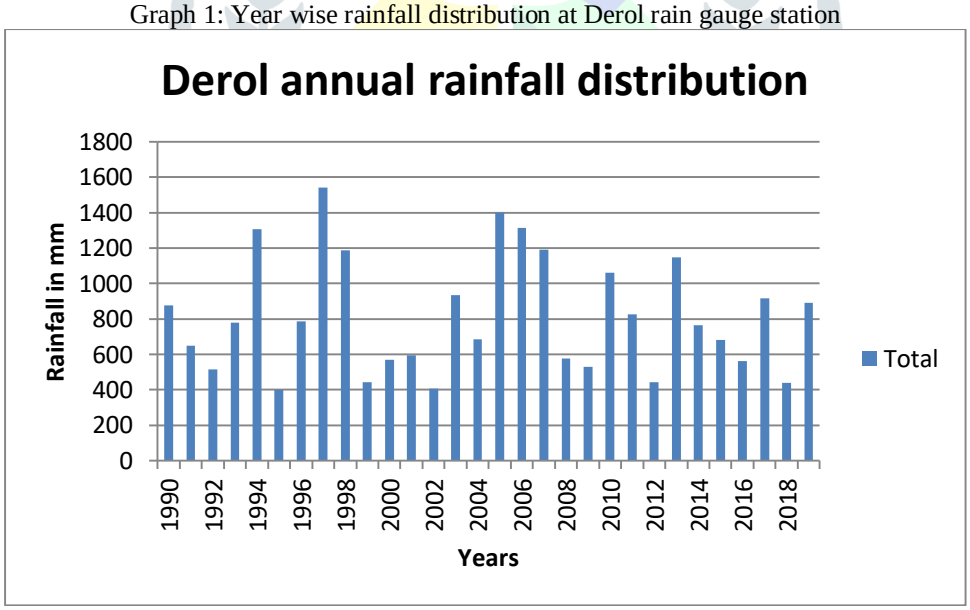
Table 1: Year wise rainfall details of three rain gauge stations

Years	Sum of Derol Rainfall(mm)	Sum of Jotasan Rainfall(mm)	Sum of Kheroj Rainfall(mm)
1990	876.00	727.35	792.60
1991	648.14	480.93	514.44
1992	514.00	644.52	1145.30
1993	777.10	663.82	694.00
1994	1305.00	1125.50	1126.60
1995	399.40	339.81	622.80
1996	784.90	760.71	763.20
1997	1540.20	1021.28	681.40
1998	1186.20	760.30	610.20
1999	444.17	471.08	471.08
2000	570.44	554.71	554.71
2001	594.00	626.80	600.00

2002	407.00	403.00	319.23
2003	934.02	588.97	950.20
2004	686.34	654.41	654.41
2005	1399.00	854.97	989.10
2006	1313.80	1469.04	1443.70
2007	1189.00	1126.80	955.80
2008	574.98	493.20	584.82
2009	528.60	662.33	590.61
2010	1060.79	997.17	997.17
2011	825.00	709.42	709.42
2012	443.40	726.00	756.60
2013	1148.80	767.80	888.00
2014	764.20	817.60	595.80
2015	681.20	1159.20	1099.00
2016	563.00	982.00	743.60
2017	914.20	931.30	1164.80
2018	438.51	470.29	470.29
2019	892.16	926.07	1174.60
Grand Total	**24403.55**	**22916.38**	**23663.48**

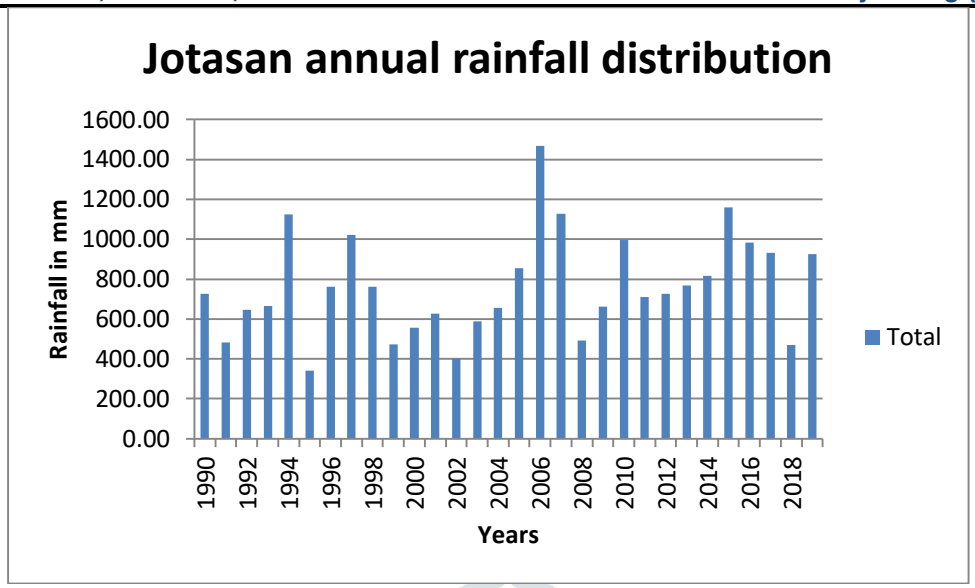
From the table, the maximum years of rainfall (where rainfall readings were recorded above 1000 mm) at Derol rain gauge station are 1994 (1305.00mm), 1997 (1540.20mm), 1998 (1186.20mm), 2005 (1399.00mm), 2006 (1313.80mm), 2007 (1189.00mm), 2010 (1060.79mm) and 2013 (1148.80mm) and minimum year of rainfall (where rainfall readings were recorded below 400 mm) is 1995 (399.40mm). The maximum years of rainfall at Jotasan rain gauge station are 1994 (1125.50mm), 1997 (1021.28mm), 2006 (1469.04mm), 2007 (1126.80mm) and 2015 (1159.20mm) and minimum year of rainfall is 1995 (339.81mm). Similarly the maximum year of rainfall at Kheroj rain gauge station are 1992 (1145.30mm), 1994 (1126.60mm), 2006 (1443.70mm), 2015 (1099.00mm), 2017 (1164.80mm) and 2019 (1174.60mm) and minimum year of rainfall recorded is 2002 (319.23mm).

Graph 1: Year wise rainfall distribution at Derol rain gauge station



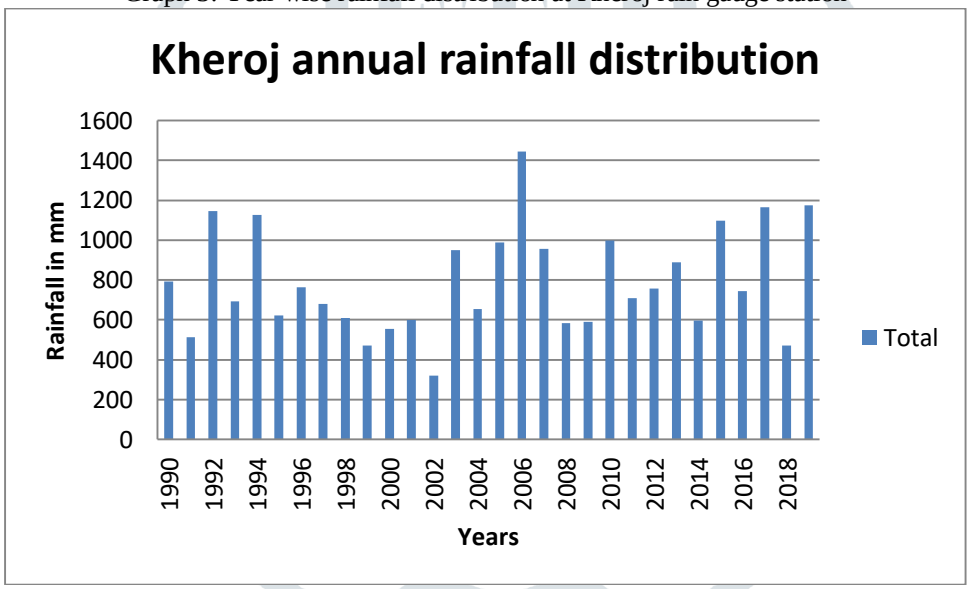
The graph represents the yearly rainfall readings recoded in mm at Derol rain gauge station. The maximum years of rainfall reading recorded (where rainfall readings were recorded above 1000 mm) in 1994, 1997, 1998, 2005, 2006, 2007, 2010 and 2013 and minimum years (where rainfall readings were recorded below 400 mm) of rainfall readings recorded in 1995.

Graph 2: Year wise rainfall distribution at Jotasan rain gauge station



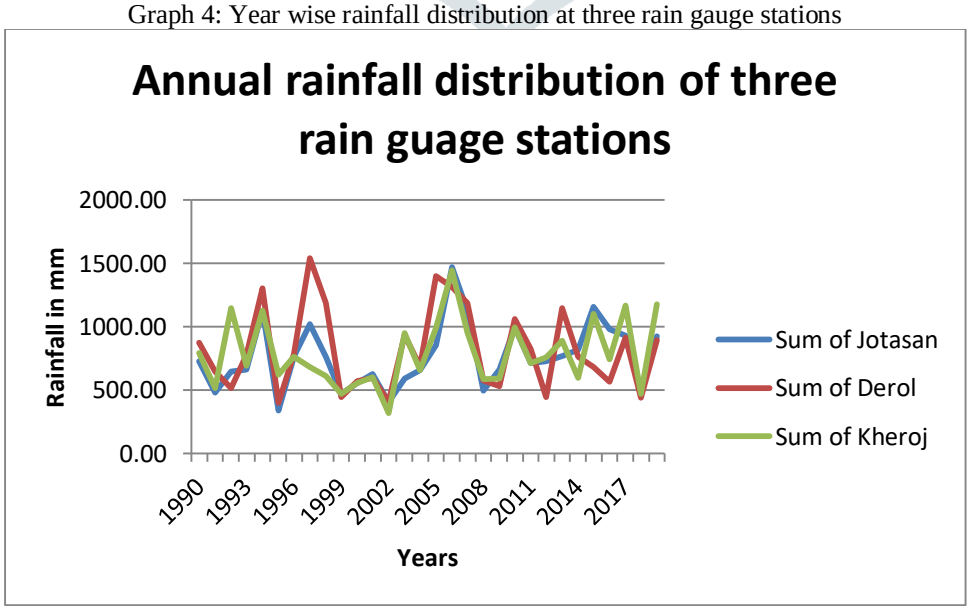
The graph represents the yearly rainfall readings recoded in mm at Jotasan rain gauge station. The maximum years of rainfall reading recorded in 1994, 1997, 2006, 2007 and 2015 and minimum years of rainfall recorded in 1995 respectively.

Graph 3: Year wise rainfall distribution at Kheroj rain gauge station



The graph represents the yearly rainfall readings recoded at Kheroj rain gauge station. The maximum years of rainfall reading recorded in 1992, 1994, 2006, 2015, 2017 and 2019 and minimum years of rainfall recorded in 2002.

Graph 4: Year wise rainfall distribution at three rain gauge stations



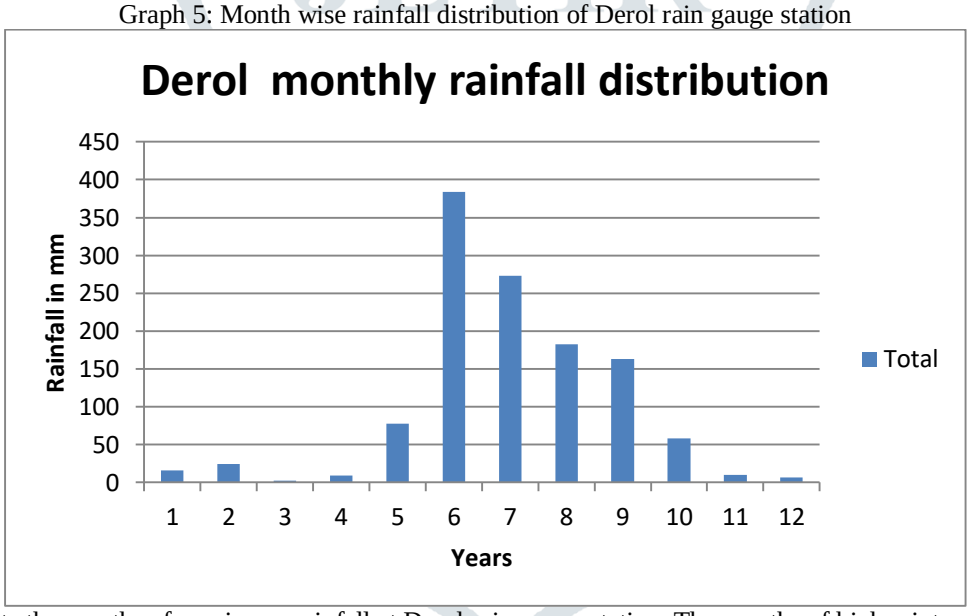
This graph represents the maximum years of rainfall at the three rain gauge stations namely derol, jotasan and kheroj station. From the graph it is seen that derol rain gauge station has peak rainfall readings recorded in 1997 and the minimum reading in 2002.

Table 2: Month wise rainfall details of three rain gauge stations

Months	Max of Derol	Max of Jotasan	Max of Kheroj
1	15.50	8.20	9.50
2	24.20	8.39	42.00
3	2.00	13.10	31.20
4	9.40	39.80	11.80
5	78.00	43.15	43.15
6	383.90	127.60	181.80
7	273.40	323.20	238.80
8	182.40	287.40	194.20
9	162.80	130.80	203.50
10	58.20	31.00	58.80
11	10.33	16.14	16.14
12	6.65	5.48	4.00

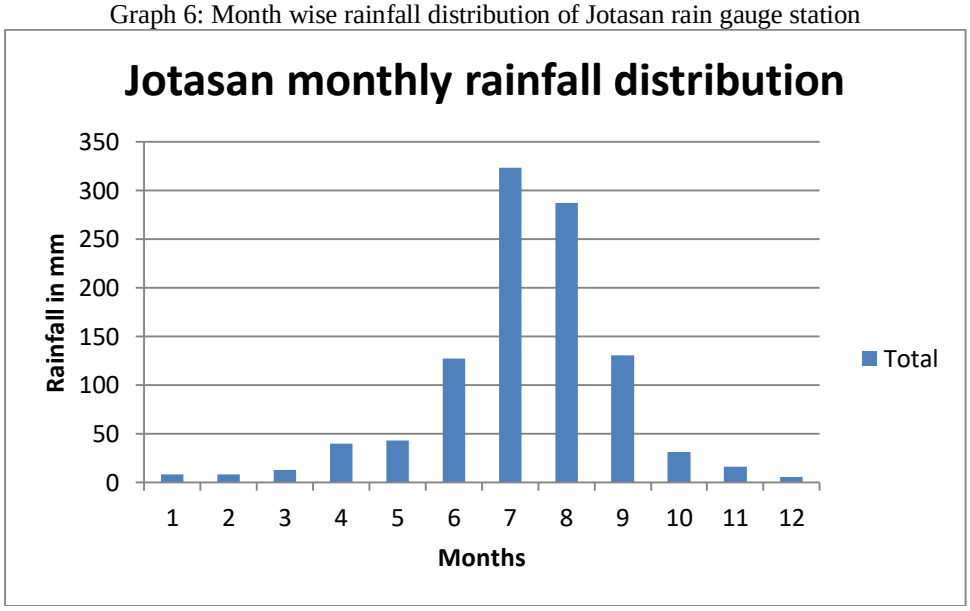
The table represents the month wise maximum rainfall readings recorded at the three rain gauge stations of the Sabarmati River. From the table, the months of maximum rainfall (where rainfall readings were recorded above 200 mm) at Derol gauge station are June (383.90mm) and July (273.40mm). Similarly, the months of maximum readings recorded at Jotasan gauge station are July (323.20mm) and August (287.40mm). The month of maximum readings recorded at Kheroj gauge station is July (238.80mm) and September (203.50mm).

Graph 5: Month wise rainfall distribution of Derol rain gauge station



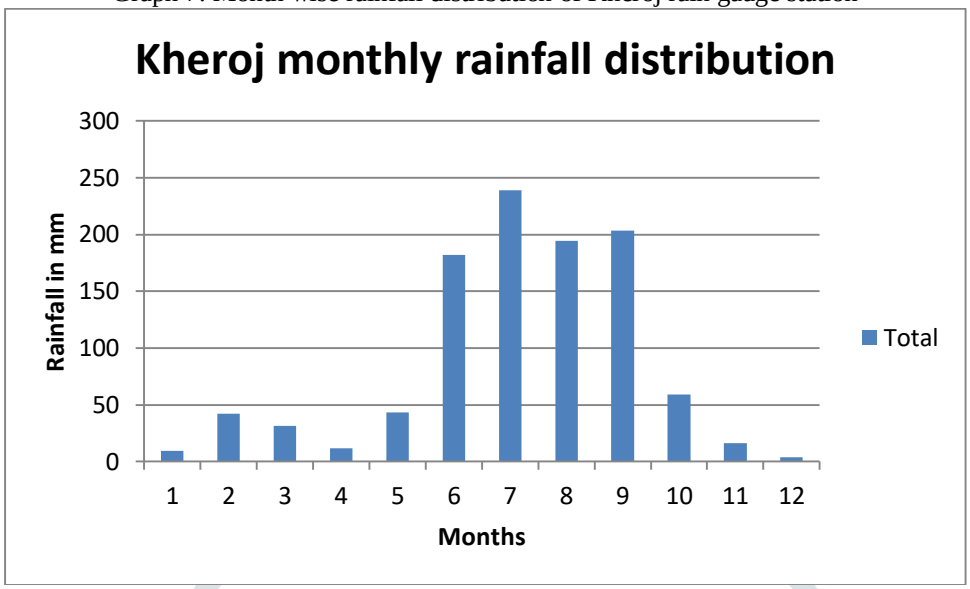
This graph represents the months of maximum rainfall at Derol rain gauge station. The months of higher intensities (above 200 mm) of rain fall are June and July.

Graph 6: Month wise rainfall distribution of Jotasan rain gauge station



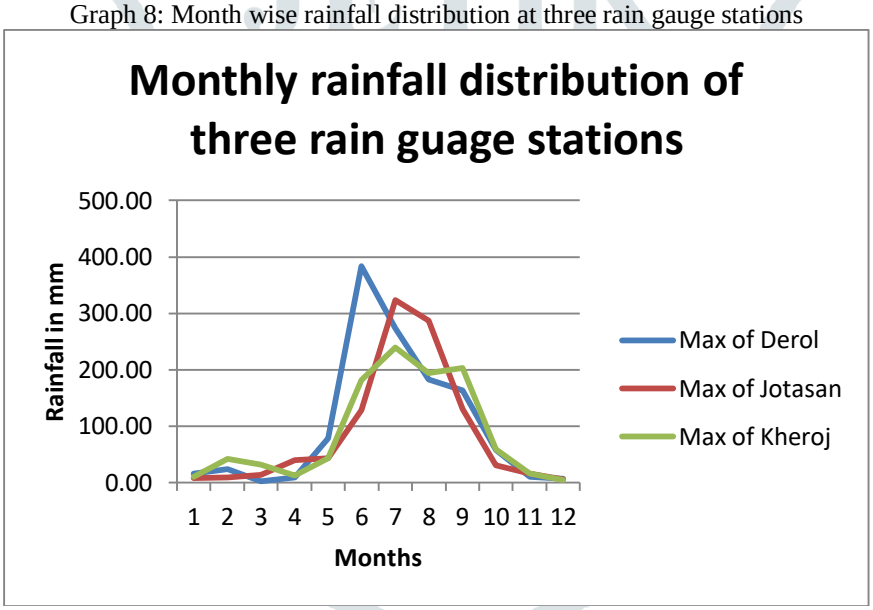
This graph represents the months of maximum rainfall at Jotasan rain gauge station. The months of higher intensities of rain fall are July and August.

Graph 7: Month wise rainfall distribution of Kheroj rain gauge station



This graph represents the months of maximum rainfall at Kheroj rain gauge station. The month of higher intensities of rain fall is July and September.

Graph 8: Month wise rainfall distribution at three rain gauge stations



This graph represents the monthly maximum rainfall at the three rain gauge stations namely Derol, Jotasan and Kheroj station. From the graph it is seen that Derol gauge station has peak rainfall readings in June month than other two recording stations.

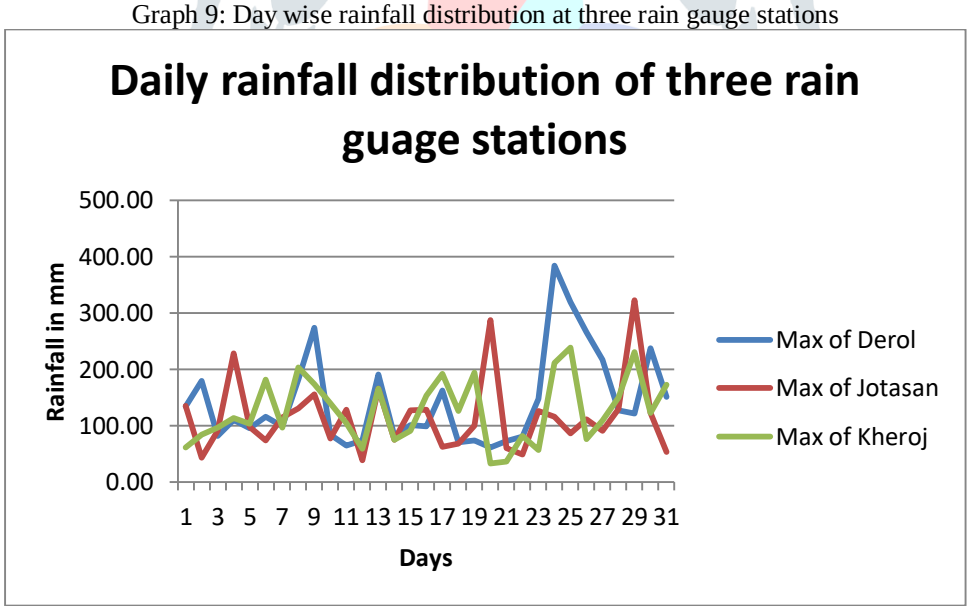
Table 3: Day wise rainfall details of three rain gauge stations

Days	Max of Derol Rainfall(mm)	Max of Jotasan Rainfall(mm)	Max of Kheroj Rainfall(mm)
1	134.40	135.60	62.00
2	180.00	43.80	83.80
3	82.40	90.60	96.80
4	110.00	228.80	113.50
5	96.00	97.40	103.90
6	115.64	73.99	181.40
7	98.80	114.54	96.50
8	182.40	130.80	203.50
9	273.40	155.80	174.40
10	84.80	77.80	139.60
11	65.40	128.00	104.80
12	74.58	38.60	58.93
13	191.22	166.51	166.51
14	81.62	75.34	75.34

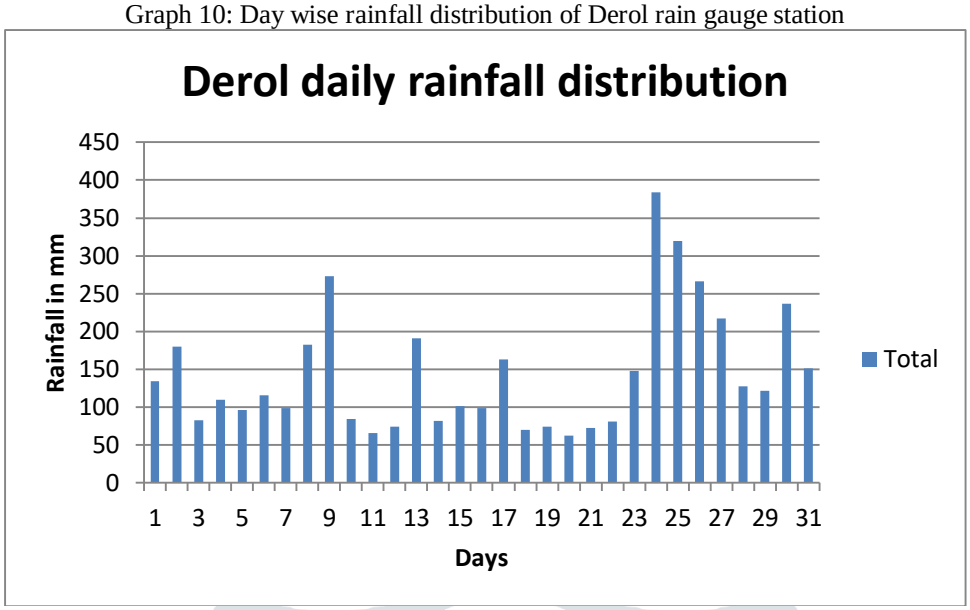
15	101.40	127.60	90.60
16	98.60	129.00	153.60
17	162.80	62.58	192.00
18	70.14	68.27	126.60
19	73.98	100.40	194.20
20	62.00	287.40	33.40
21	72.40	60.15	36.98
22	80.60	49.25	82.40
23	147.88	126.57	56.80
24	383.90	115.80	211.40
25	319.60	86.40	238.80
26	266.40	111.69	76.60
27	216.80	91.00	109.80
28	127.60	129.20	150.40
29	121.80	323.20	230.60
30	237.00	123.11	123.11
31	151.60	54.19	173.00
Grand Total	**383.90**	**323.20**	**238.80**

The table represents the daily maximum rainfall readings recorded at the three rain gauge stations of the Sabarmati River. From the table, the days of maximum rainfall (where rainfall readings were recorded above 200 mm) at Derol gauge station are 9 (273.40mm), 24 (383.90mm), 25 (319.60mm), 26 (266.40mm), 27 (216.80mm) and 30 (237.00mm). Similarly, the days of maximum readings recorded at Jotasan gauge station are 4 (228.80mm), 20 (287.40mm) and 29 (323.20mm). The days of maximum readings recorded at Kheroj gauge station are 8 (203.50mm), 24 (211.40mm), 25 (238.80mm) and 29 (230.60mm).

Graph 9: Day wise rainfall distribution at three rain gauge stations

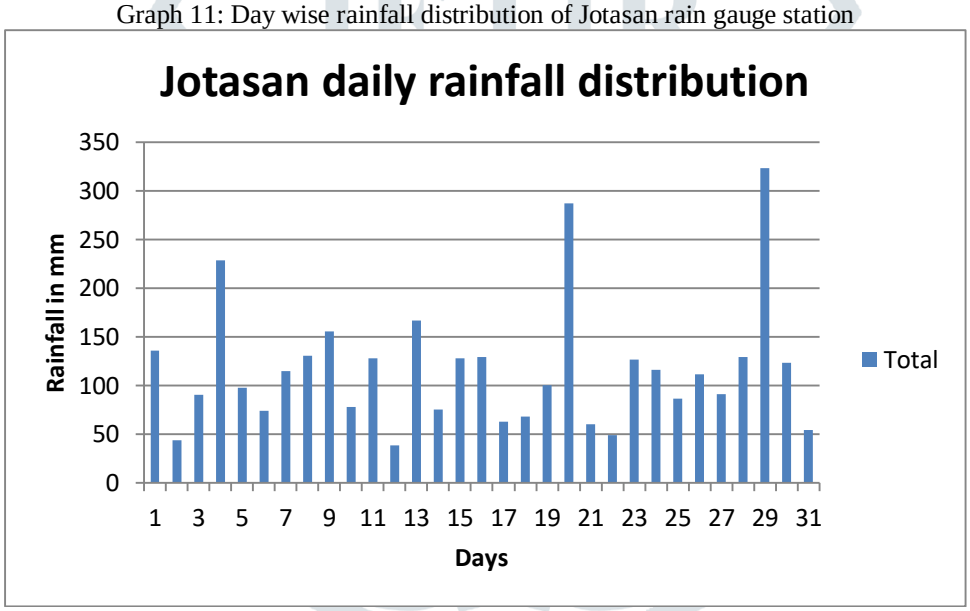


Graph 10: Day wise rainfall distribution of Derol rain gauge station



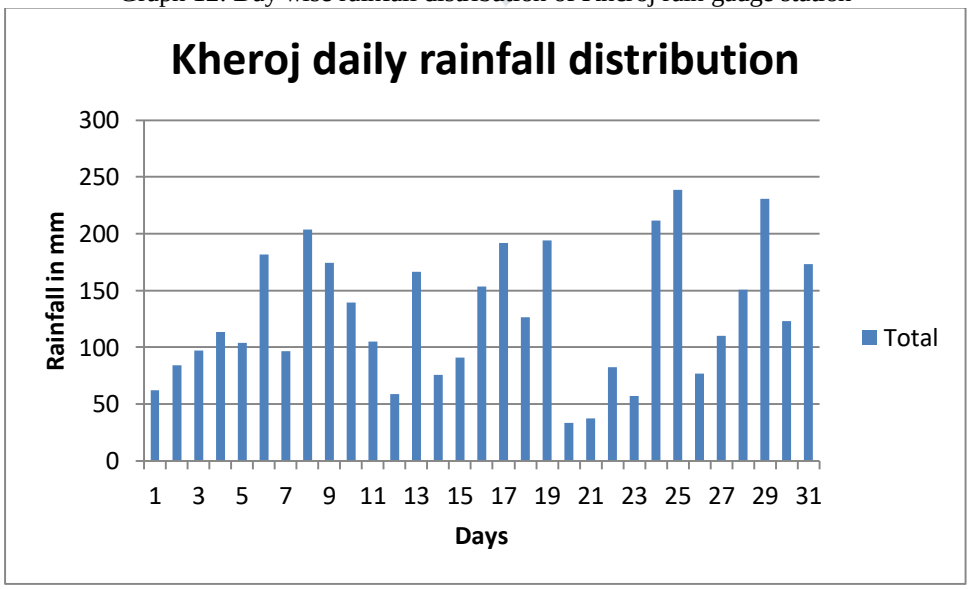
This graph represents the maximum daily rainfall in Derol rain gauge station. From the graph it is seen that the intensity of rainfall has tremendously increased for 6 days (above 200mm) only from 31 days.

Graph 11: Day wise rainfall distribution of Jotasan rain gauge station



This graph represents the maximum daily rainfall in Jotasan rain gauge station. From the graph it is seen that the intensity of rainfall has tremendously increased for 3 days only (above 200mm) from 31 days.

Graph 12: Day wise rainfall distribution of Kheroj rain gauge station



This graph represents the maximum daily rainfall in Kheroj rain gauge station. From the graph it is seen that the intensity of rainfall is increased (above 200mm) for 4 days only from 31 days in this rain gauge station.

VI. CONCLUSIONS:

From the study it was concluded that the annual peak rainfall decreased at Jotasan and Kheroj rain gauge stations in the upstream of the reservoir whereas in the plain areas (downstream) of the basins show increasing annual peak rainfall recorded at Derol rain gauge station. The monthly peak rainfall decreased from four months (June, July, August & September) to two months (June and July) only in upstream as well as downstream areas. And the peak rainy days have considerably decreased from 6 to 4 days in catchment areas of the basins. This has resulted in flash floods in plain areas of the basins. Hence in order to conserve our natural environment the anthropogenic activities should be considerably decreased to restore our previous rainy days of constant rainfall.

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