



SPATIO-TEMPORAL ANALYSIS OF RAINFALL DISTRIBUTION AND VARIABILITY OVER THE DROUGHT – PRONE TAHSILS IN JALGAON DISTRICT OF MAHARASHTRA STATE

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Abstract: The study area is located in the drought-prone areas of Jalgaon district in North part of the Maharashtra state- The major occupation of the people in this region is farming which is mostly rainfed, whereas inter annual and seasonal variability is high and droughts are frequent in this region. Crop production in this semi-arid region is largely determined by climatic and soil factors. Rainfall is the limiting factor in these areas. It governs the crop yields and determines the choice of the crops that can be grown. Therefore, a detailed knowledge of regime is an important prerequisite for agricultural planning.

Analysis of rainfall of the study is based on 31 years (1980-2010) of monthly, seasonal and annual rainfall data for a 9 rain gauge stations. While analyzing the long-term average of monthly and annual rainfall, the annual rainfall of the study area is 682.78mm, of which the winter, summer, southwest and northeast monsoon record 6.12, 14.29, 594.37 and 68.00mm respectively. The station, Amalner receives the highest rainfall of 1639.6mm in the year 1992, whereas Erandol records the lowest of 267mm in the year 1982. The region receives the highest average rainfall of 1082.11mm in the year 1998 and lowest average rainfall of 444.73mm in the year 2000. The annual variability ranges from 23% to 37%. The southern part of the region experiences the heavy rainfall, whereas the west, north, northeast part of the region experiences the lowest rainfall. The shaded region shows significant correlation coefficient with 5% level of significance.

Keyword: Annual and seasonal rainfall, rainfall variability, trend and Precipitation ratio.

1. Introduction: Of all conditions, rainfall should be regarded as the fundamental so far as

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Received on: October 2017

Accepted after revision: November 2017

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progress of the society is concerned. Rather, it has always been treated as a fundamental sector for the total development of the society S.K. Tripathi, (2009). Rainfall is a crucial agro-climatological factor in the seasonally arid parts of the world and its analysis an important prerequisite for agricultural planning in India, Alaka Gadgil, (1986). India is a tropical

country; its agricultural planning and utilization water depends on Monsoon rainfall, more than 75% of rainfall occurring during monsoon season; monsoon rainfall is uneven both in time and space, so it is important factor to evolve the rainfall analysis. G. Vennila, (2007) has analyzed rainfall variation of Vettamalikalrai Subbasin, Tamilnadu, India. The rainfall is variable which changes both in space and time T. Penchalain, (1992). The relation between rainfall and space and time varies, which determines the environment and development of a particular region. The rainfall processes are known to exhibits a high degree of variability both in space and time L.G. Lanza, (2001). Climate change is very likely to have a major impact on hydrological cycle and consequently on available water resources, flood and drought frequencies, natural and manmade ecosystem, society and economy, Evans, (1996). S.K. Tripathi, (2009) has analyzed the rainfall analysis for crop planning.

Recent research reported a statistical evidence of changing tendency of Indian monsoon rainfall; the findings suggest that the monsoon precipitation variability might be remarkably complex. Inter regional differences suggest a fairly higher degree of local influence on variability Goswami et al, (2006) examined the distribution and trend of moderate daily monsoon rainfall over central India and found a decreasing trend and increasing variability of the same, many other similar studies have been taking place in various other parts of the globe, which are also going through decreasing trends of precipitation.

The government of Maharashtra and central government declared 9 tahsils in Jalgaon district drought-prone areas. They are Amalner, Parola, Dharangaon, Erandol, Bhadgaon, Pachora, Chalisgaon, Jamner and Muktainagar. The present study helps to understand the rainfall of the region- including Chalisgaon, Bhadgaon,

Jamner, and Pachora tahsils located nearby the Hatti, Ajanta, Satmala ranges and Chandor hills, these rain gauge stations receive more rainfall than nearby lowlands, especially in their windward sides as a result of orographic lifting characters of the region A.A. Adebaye(1997). The influence of topography is on rainfall distribution. However, the study reflects the more rainfall in the windward of Hatti, Ajanta, and Satmala ranges region, which includes the spatial variation, variability through different seasons for the period from 1980 to 2010 in order to contribute to a better interpretation of its hydrological status. The precipitation regime features a high seasonal and annual variability in both temporal and spatial domains; provide a general gauge regarding changes in the natural behavior of ecosystems, a key step in this process is the ability to reveal that a change or trend is present in the rainfall records.

2. Aims and Objectives: The present study has been undertaken with following specific objectives:

- i) To study the annual rainfall from the year, 1980 to 2010
- ii) To analyze rainfall variability at annual and seasonal time scale for agricultural planning
- iii) To find out co-efficient of variation and show the variation in groups as a shaded part in map

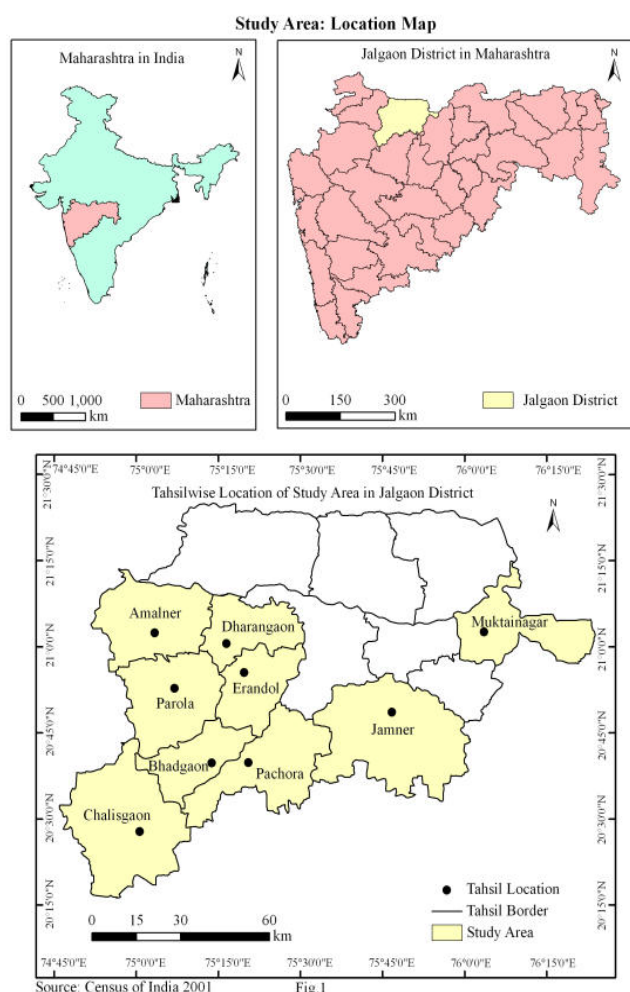
3. Study area: The Maharashtra government and central government declared 9 drought-prone tahsils in Jalgaon district. These tahsils are Amalner, Parola, Dharangaon, Erandol, Bhadgaon, Pachora, Chalisgaon, Jamner and Muktainagar. These 9 drought-prone tahsils have been selected for the present study which covers an area of about 6994.50 sqKm. The area under study is at south of the Tapi river in Jalgaon district. In the East the area is bordered by the Buldhana district, to the south the Hatti, Ajanta, Satmala ranges and Chandor hills form a natural boundary between the study area and the district of Aurangabad and Nasik, the West is

surrounded by Dhule district and to the North Tapi River. It lies between 20° 15' to 20° 08' north latitudes and 74° 20' to 76° 20' east longitudes (Fig.1). The population of the study area is 21, 21832 as per 2011 census. The remarkable feature of the states rainfall is that it decreases rapidly to the east of the Sahyadri ranges and increases slightly to the east of the study area. In the study region there has been remarkably scanty rainfall. It is agriculturally imbalanced region. The region has good drainage network, but still is facing a problem of shortage of water for domestic and irrigation purposes. Therefore, there is an urgent need to access the potential and utilization of water resources in drought-prone areas in Jalgaon district.

of study area has been prepared from survey of India Toposheet on 1:250,000 scale. The present study is based on the rainfall (mm) data collected from Indian meteorological Department, Pune for 31 years from 1980 to 2010, for 9 rain gauge stations, Socio-economic Review of Jalgaon district. There are 9 rain gauge stations which have been taken into consideration for analyzing long-term mean monthly, seasonal and annual rainfall trend, variability, coefficient of variability has been calculated and represented along with descriptive statistics, measures of central tendency, measures of dispersion, correlation analysis, variability analysis also additional statistical tools and techniques could be utilized as and when required for rainfall analysis in drought-prone areas in Jalgaon district and shows the presentation of result with the help of charts maps and diagrams and choropleth cartographic method is used.

5. Result and Discussion

5.1 Rainfall distribution in study area: The highest yearly average tahsil rainfall during the last 31 years is 1639.6mm in Amalner tahsil in 1992, whereas lowest rainfall recorded as 267mm in Erandol tahsil in 1982. Study area received highest yearly average rainfall which is 1082.18mm in 1998 and lowest rainfall, 444.73mm in 2000 during the last 31 years (1980-2010). The southern part of the study area received heavy rainfall, especially, Jamner, Chalisgaon and Bhadgaon tahsils. The average yearly rainfall in these tahsils is 770, 738 and 703 mm respectively. On the other hand, west, north and east parts of the study area received less annual average rainfall that the southern part, especially, Amalner, Muktainagar and Dharangaon tahsils average yearly rainfall is 630, 638 and 641mm respectively during the last 31 years. In short, the average annual rainfall in the study area varies from part to part (Table -1 & Graph - 1).



4. Database and Methodology: The base map

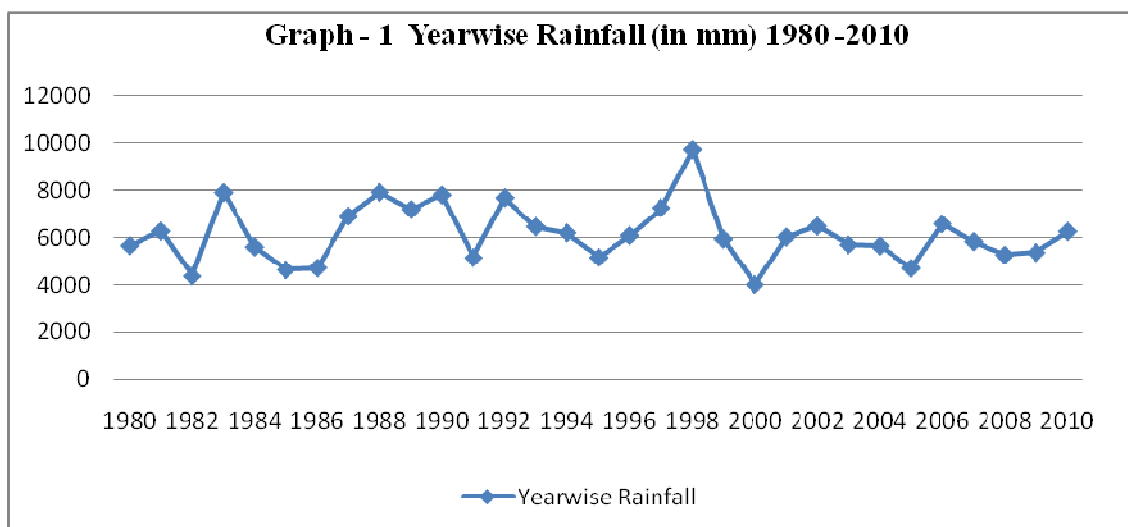


Table -1 Tahsil wise Inter –annual rainfall (mm) 1980-2010

Year	Chalisingaon	Bhadgaon	Pachora	Erandol	Dharangaon	Parola	Amanlner	Jamner	Muktainagar	Total
1980	698	648	640	376	462	592	549	1334	363	629
1981	735	628	636	499	574	752	650	1178	617	696
1982	547	441	499	267	385	633	503	599	482	484
1983	822	926	927	941	911	1270	881	832	398	879
1984	791	494	382	531	641	1018	751	581	413	622
1985	613	519	628	410	460	521	511	557	409	514
1986	713	517	509	533	501	469	388	554	531	524
1987	1107	817	830	661	672	739	683	836	561	767
1988	1004	940	1030	917	835	703	754	761	979	880
1989	1199	1043	876	553	570	607	587	972	787	799
1990	808	915	838	1145	973	631	800	1053	645	868
1991	693	536	481	750	630	442	511	623	482	572
1992	682	738	621	842	901	877	1640	844	545	854
1993	891	732	741	680	587	624	493	773	941	718
1994	527	675	402	724	690	788	656	887	850	689
1995	527	614	539	522	490	630	457	759	618	573
1996	849	835	879	532	592	621	651	596	533	676
1997	1003	961	805	794	671	780	574	887	785	807
1998	1183	1138	1216	1010	1015	1032	1023	1104	1020	1082
1999	626	653	553	708	650	869	591	695	592	660
2000	316	493	328	506	414	520	321	621	483	445
2001	653	644	570	701	630	824	559	857	587	669
2002	926	605	587	853	687	685	522	678	940	720
2003	630	629	651	692	595	638	498	713	650	633
2004	506	628	565	589	614	603	705	722	716	628
2005	450	606	568	505	572	532	403	600	468	523
2006	1001	1016	680	688	630	623	574	678	693	732
2007	534	481	793	660	660	654	622	764	664	648
2008	623	687	597	664	547	573	506	595	470	585
2009	576	527	552	686	633	522	589	684	595	596
2010	633	694	777	742	681	642	580	544	965	695
Total	737.60	702.50	667.65	667.05	641.03	690.80	630.13	770.30	638.06	683

Source: India Meteorological Department, Pune

5.2 Variation of Monthly Rainfall: The variation of rainfall of the study area takes in every month and the intensity of rainfall is very high from June to September and suddenly

decreases down from October to December and also from May to January (Table – 2 & Graph - 2). The high intensity of rainfall trend declines in the month of April and also from October to December. There is the lowest rainfall in the month of April. However, Amalner tahsil records maximum rainfall 917.6mm in the month of July and it experiences lowest rainfall in month of January which is 1.8mm. The

lowest rainfall recorded at Erandol tahsil is 0.00mm in the month of February and its maximum rainfall is 387.6mm in the month of July. Jamner, Chalisgaon and Bhadgaon tahsils experience heavy rainfall in the month of August and July. The Erandol, Dharangaon, Amalner and Parola tahsils experience low rainfall during these months.

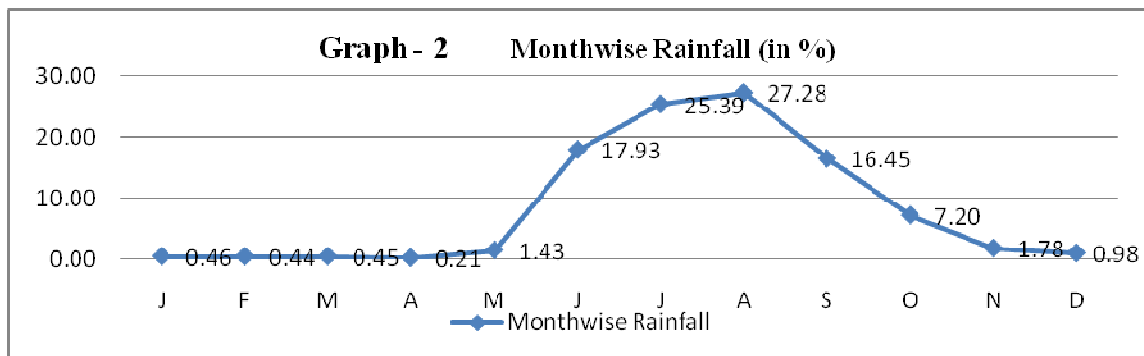
Table -2 Month wise inter annual rainfall in mm 1980-2010

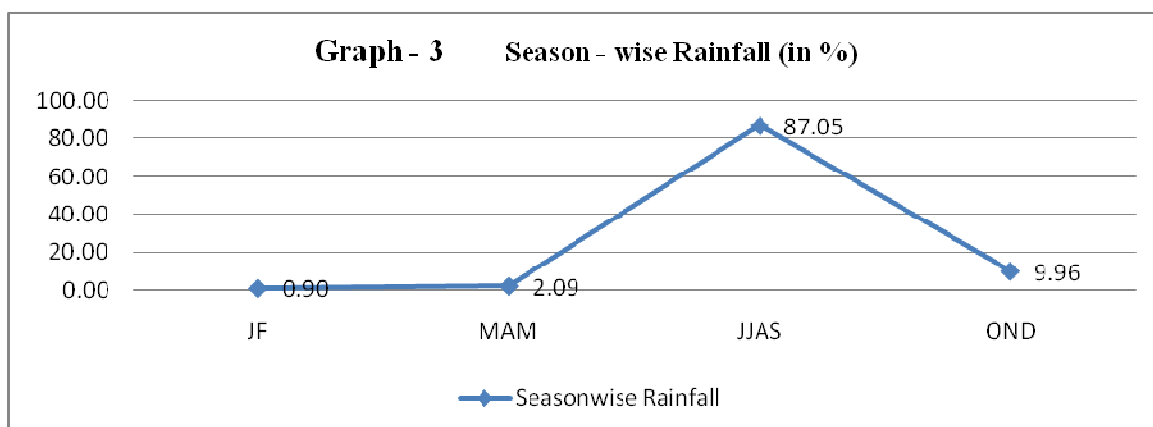
Year	J	F	M	A	M	J	J	A	S	O	N	D	Annual
1980	0	0	4	0	0	1939	658	2467	390	9	2	191	709.2
1981	107	11	15	0	22	596	1588	2062	1332	357	74	106	850.1
1982	80	0	4	13	32	1056	1209	1016	537	166	244	0	330.4
1983	0	0	0	0	0	1026	1901	2225	2187	550	18	1	847.2
1984	31	67	0	0	0	628	1827	1459	883	683	24	0	607.8
1985	0	0	0	29	6	750	1579	1129	351	761	22	0	588.5
1986	12	145	32	0	0	938	1050	2052	313	13	42	119	621.3
1987	90	103	38	0	185	1465	1093	2354	332	533	517	194	699.2
1988	0	0	0	24	27	913	2511	1180	2807	401	43	14	630.0
1989	0	0	301	1	37	1361	1839	2521	1021	63	36	14	769.6
1990	17	0	0	0	386	813	1222	3200	1060	922	83	105	900.8
1991	0	0	41	16	0	1983	2157	672	193	35	51	0	530.5
1992	0	0	0	0	19	1675	2011	2057	1014	901	12	0	852.3
1993	0	7	31	0	33	575	2145	1205	1472	484	111	400	690.3
1994	5	0	0	38	6	1032	1653	1916	1258	212	79	0	713.9
1995	207	1	205	35	64	782	1505	522	1083	753	0	1	632.1
1996	0	0	0	0	0	384	1550	1793	1371	974	15	0	700.2
1997	87	0	0	30	0	783	1523	1997	802	590	823	625	678.8
1998	0	0	11	0	0	1253	2665	2341	2584	692	183	10	781.6
1999	0	163	0	0	47	1676	1091	858	1064	1008	28	0	855.5
2000	0	0	0	0	0	1787	1621	330	221	11	0	32	327.3
2001	130	0	46	0	5	1349	1052	1677	406	1361	0	0	825.1
2002	30	119	5	5	0	1561	412	2515	1431	160	244	0	629.9
2003	14	44	0	27	199	1208	1210	1709	802	361	113	10	654.4
2004	0	0	0	0	337	739	1431	1424	1452	175	90	0	825.4
2005	10	0	12	61	124	883	1517	1159	668	202	57	10	409.1
2006	10	37	23	19	228	1146	1790	1847	1024	320	125	15	768.3
2007	0	64	0	32	291	931	1749	1635	740	305	68	16	660.7
2008	7	13	63	12	258	960	1592	1403	648	240	66	0	675.1
2009	25	21	23	19	191	923	1567	1352	954	184	104	0	623.1
2010	14	38	11	35	234	1043	1654	1885	932	281	118	12	782.0
Average	3.1	3.0	3.1	1.3	9.8	122.3	172.2	187.0	111.8	50.2	12.1	6.7	682.8
%	0.5	0.4	0.5	0.2	1.4	17.9	25.2	27.4	16.4	7.4	1.8	1.0	100

Source: Computed by the researcher

Table – 3 Season wise inter annual rainfall in mm 1980-2010					
Year	JF	MAM	JJAS	OND	Annual
1980	0	4	5455	202	5661
1981	118	36	5578	537	6268
1982	80	49	3818	410	4356
1983	0	0	7339	569	7908
1984	98	0	4797	707	5602
1985	0	35	3810	783	4628
1986	157	32	4353	174	4716
1987	193	223	5244	1244	6905
1988	0	51	7411	459	7921
1989	0	339	6741	113	7193
1990	17	386	6296	1110	7809
1991	0	57	5005	86	5147
1992	0	19	6757	913	7689
1993	7	64	5397	995	6462
1994	5	44	5860	291	6200
1995	208	303	3892	754	5156
1996	0	0	5098	989	6087
1997	87	30	5104	2038	7260
1998	0	11	8844	885	9740
1999	163	47	4690	1036	5936
2000	0	0	3960	43	4003
2001	130	51	4484	1361	6025
2002	149	10	5919	404	6482
2003	58	226	4929	484	5697
2004	0	337	5046	265	5648
2005	10	197	4228	269	4704
2006	47	270	5807	459	6584
2007	64	323	5056	390	5833
2008	20	333	4603	306	5262
2009	46	233	4796	288	5363
2010	52	280	5514	411	6256
Total	1709	3988	165828	18973	190498
%	0.90	2.09	87.05	9.96	100

Source: Computed by the researcher





5.3 Mean Annual Rainfall: The long term mean annual rainfall of the region is 682.78mm. The region is characterized with unique aerial topography because of Hatti, Ajanta, Satmala ranges and Chandor hills. The southern part of the study area is bounded with the above ranges and foothills (Graph - 1). The most of the foot hills of the region will get the maximum rainfall during all seasons. The most of the foothill region is in the windward for the upland region such as Chalisgaon, Pachora, and Jamner tahsils, which will get more than 750mm rainfall. However, the western north-central and northeastern parts of the region such as Amalner, Dharangaon, Erandol, Parola and Muktainagar tahsils located at the leeward of upland region naturally get very less rainfall of 400mm and some central part of the region will get good amount of rainfall. The southern part of the region will experiences maximum rainfall and these places are called wettest parts of region such as Jamner and Chalisgaon tahsil.

5.4 Rainfall Zones

1. High rainfall zone (above 700mm) in the southern part Chalisgaon, Pachora and Jamner tahsils
2. Moderate rainfall zone (650-700mm) Pachora, Erandol and Parola tahsils
3. Low rainfall zones (Below 600mm) Amalner, Edlabad, and Dharangaon tahsils

5.5 Winter season Rainfall: The winter season average rainfall is 6.12mm and it contributes 0.9% to annual rainfall (Graph -3). This season heavily experiences low rainfall and it is driest among all the seasons in the southern part of

upland region in study area in Jalgaon district. The southern upland part will experience the high pressure area during this season due to the low temperature and the availability of moisture will be very less. The maximum rainfall recorded at adjacent area of the region at Jamner is 72.7mm in the month of January in 1987 and lowest recorded at Jamner which is 1.3mm in the month of January in 1986. The amount of rainfall decreases north, northwest and northeast parts of region such as Erandol, Dharangaon, Amalner, Edlabad tahsil.

5.6 Summer season Rainfall: Summer is hottest weather-season. The amount of rainfall gradually increases and however the amount of rainfall occurrence in this season is largely due to convection effect. The maximum rainfall recorded at Bhadgaon tahsil which is 104mm is in the month of May in 1990 and minimum, 49mm in the month of March at Erandol tahsil in 1995 (Graph - 3), during this season the area experiences the low pressure due to high temperature and most of the rain occurs with convection effect. The characteristic of this season is high humidity and almost area deficits in the shortage of drinking water. This season contributes 2.09% of mean annual rainfall. The average rainfall in this season is 14.29mm. The Chalisgaon, Jamner and Pachora tahsils located at foothill of Hatti, Ajanta and Satmala ranges and it is tip of windward it will get maximum rain, however the leeward places of the region experiences low rainfall. The 95% of area under the leeward such as Amalner, Erandol,

Dharangaon, Parola, and Muktainagar get low rainfall.

5.7 Southwest Monsoon season rainfall: The amount of rainfall during this season comparatively to winter and summer has been good. The high amount rainfall variation can be found during this season. The adjacent upland tahsils get good rain during the post monsoon season, even though the influences of southwest monsoon season of India generally gets good rain. The average rainfall of this season is 594.37mm and it contributes 87.05% of annual rainfall even though this season contributes good amount of rainfall, but not in the uniformity (Graph – 3 & Table - 3). However, the southwest monsoon gives high amount of rainfall variation in comparison with other seasons. The highest seasonal rainfall recorded in Amalner tahsil is 1499.4mm in 1992 and 239mm at Erandol in 1982. The highest mean average rainfall of southwest monsoon season is 664.47 at Jamner tahsil and lowest mean average is 544.69mm at Edlabad tahsil.

The tahsil wise monthly highest mean rainfall of southwest monsoon season recorded at Jamner tahsil, which is 211.64mm in the month of August and the lowest in Amalner which is 148.21mm in the August month. The tahsilwise monthly highest mean rainfall of southwest monsoon season is 190.46mm at Jamner tahsil in July and lowest is 157.66mm at Edlabad in July. The tahsilwise monthly highest mean rainfall of southwest monsoon season recorded in June month is 140.85mm at Parola and lowest is 99.24mm at Dharangaon tahsil. The tahsilwise monthly highest mean rainfall southwest monsoon season of September month is 146.79mm at Chalisgaon tahsil and lowest which is 93.55mm at Dharangaon. The monthly mean rainfall of southwest monsoon season of the study area in June is 122.43mm, July 173.39mm, August 186.25 which is the highest one and September 112.29mm. The 20% of area

experiences the heaviest rainfall during the season and rest of the area gets least amount of rainfall.

5.8 North east monsoon season rainfall: This season gets enter rain from retreat monsoon, that is, from October to December. The average rainfall of this season is 68mm and it contributes 9.96% to the annual rainfall (Graph -3 & Table - 3). Total rainfall in this season is low in comparison with the southwest monsoon rainfall. However, the entire region has uniformity in rainfall during this season. The most of the post monsoon gives good rain for the upland due to the pressure occurring during this period, the southern part of the study area gets heaviest rainfall during this season. During the northeast monsoon season the highest average rainfall recorded in the month of October is 49.13mm and it contributes to the mean annual rainfall, 7.20%. The average rainfall in November is 12.15mm and it contributes 1.78% to the mean annual rainfall. However, it is 6.72mm in December and its contribution to the mean annual rainfall is 0.98%. In the year 1997, the annual average rainfall of northeast season is 226.47mm and lowest 12.56mm in year of 1989.

The tahsilwise annual highest rainfall of northeast monsoon season is recorded at Muktainagar tahsil, which is 380.3mm in the month of October in 1988 and lowest 0.00mm at Chalisgaon tahsil in 1989. The tahsilwise highest mean rainfall of northeast monsoon season is 90.98mm at Chalisgaon tahsil and lowest 53.12mm at Erandol tahsils (Graph - 3).

5.9 Variability of Rainfall: The term, 'variability' has been defined as the deviation from mean or "ration of the standard deviation to the mean rainfall".

5.9.1 Annual Variability of Rainfall: The annual rainfall variability of study area is 20.24% which stretches between 23.69% and 37.61%. (Table -4)

Table – 4 Long term (1980-2010) mean seasonal, annual, precipitation ratio and rainfall variability (in %)

% Variability	Annual Precipitation Ratio	Winter season	Summer season	Soth-west monsoon season	PostMonsoon season	Annual
Chalisgaon	101.55	152.25	147.35	31.56	75.61	29.59
Pachora	132.93	158.46	143.32	29.87	86.51	29.21
Jamner	102.58	211.91	134.13	29.91	88.39	25.35
Bhadgaon	89.60	226.75	172.65	26.80	88.71	26.48
Amalner	118.77	224.76	129.67	40.68	87.08	37.61
Dharangaon	192.88	159.16	132.36	22.94	68.45	23.69
Erandol	104.30	158.21	171.79	31.29	116.39	28.29
Edlabad	137.18	221.62	127.07	31.34	127.63	29.47
Parola	95.05	180.19	124.71	28.79	98.28	25.88

Source: Computed by the researcher

The maximum variability of rainfall recorded at Amalner is 37.61% and lowest rainfall variability at Dharangaon tahsil is 23.69%. The maximum variability concentrating in northwest is in Amalner tahsil. The variability of rainfall distributed uniformity over study area except Amalner tahsil (Table - 4). The result shows that the rainfall deviates from normal.

5.9.2 Winter season rainfall variability: The variability rainfall is higher in this season in comparison with other season, because low rainfall areas experiences greater fluctuation of variability (Table - 4). The study area rainfall variability stretches between 152.25% and 225.75%. The lowest variability recorded at the southwest especially in Chalisgaon tahsil is 152.25%; the same is variability in Pachora tahsil located at south-central part and Erandol which is in north part of study area. The rainfall variability is same which is 158.46% and in west part. The variability has suddenly increased in the eastern part. This fluctuation in variability indicates that the eastern part experiences lowest rainfall.

5.9.3 Summer season variability of Rainfall: The rainfall variability of hot summer is well distributed and it is less than winter season. The maximum variability during this season is recorded at (Table - 4). Bhadgaon tahsil which is 172.65%, in Erandol tahsil 171.79%; and

variability generally decreases from central part to everywhere. The lowest rainfall variability area has uniformity. The lowest rainfall ranges from 124.71% to 147.32%. The study area experiences slightly low rainfall variability which is 104.31%. The rainfall variability of this season is less than winter season due to the moisture availability during monsoon free summer. Mostly the rainfall occurs through convection effect. Most of the hot areas might get good rainfall.

5.9.4 South west monsoon variability of rainfall: The south west monsoon rainfall variability experiences very less variability in comparison with other season, that is, 21.62% which is lowest. Dharangaon and Bhadgaon tahsil experience very less variability due to heavy rainfall during this season (Table - 4), whereas high variability is experienced at Amalner, which is 40.68%. Most of northwest, north and northeast parts of the study area may have some maximum variability of rainfall.

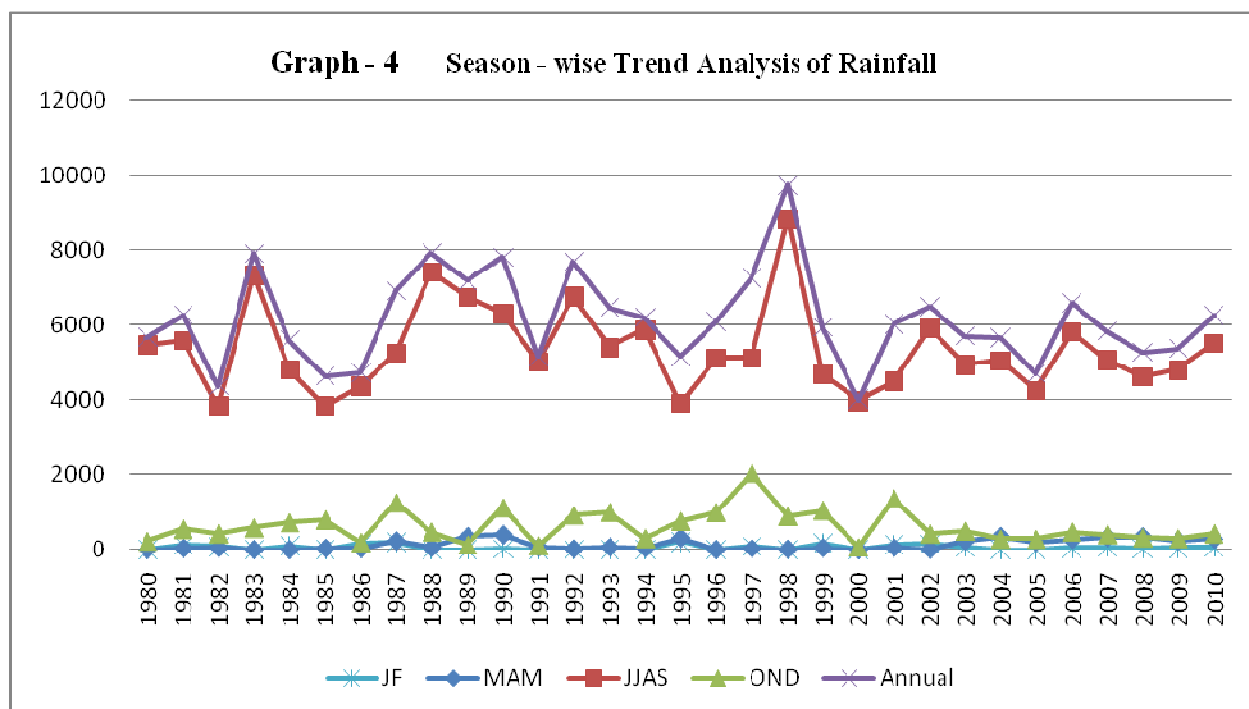
5.9.5 North East Monsoon Variability of Rainfall: The north east monsoon rainfall variability is experiences higher than the south west monsoon due to less rainfall. The rainfall variability of study area is 72.63%. It ranges from 68.45% to 127.63%. The maximum variability recorded at Edlabad, which is 127.63% and at Erandol which is 46.39% and

lowest at Dharangaon which is 68.45%, 75.61% in Chalisgaon tahsil. However, rest of the area experiences uniformity of variability (Table - 4). The north east monsoon season gives better result than the other seasons.

5.9.6 Precipitation Ratio: The abnormalities of rainfall at any location may be brought by a simple ratio of precipitation. It is the difference between maximum and minimum rainfall of over the series of expressed in terms of mean. This ration may give the stability of rainfall with special relationship. Higher is the ratio; higher is abnormality in rainfall and vice versa. The maximum abnormality at Dharangaon tahsil is 192.88% and minimum abnormality recorded at Bhadgaon tahsil is 89.60% (Table - 4). The

rainfall ratio distributed well uniformity in the south and central part of the study area especially, Chalisgaon, Jamner, Erandol, Parola and Bhadgaon and increasing abnormality in the north, west and east parts of the study area and it is not good relationship to the rainfall pattern in the north east region.

5.9.7 Monsoon Rainfall Trends: In the decade of 1980-1990 the rainfall trend of the study area annually increases about 8.61% similarly the south west monsoon season rainfall increases about 10.07% and winter rainfall also has increased 16.31%. On the other hand, summer monsoon decreases in 13.10% while north east decreases up to 0.27% (Graph – 4).



In the decade of 1990-2000 monsoon rainfall annually increases up to 0.28% to the decade 1980-1990 in which it decreases up to about 18%. Summer monsoon has significantly decreased in and 57%. Southeast monsoon

rainfall 1.21% on the other hand northeast monsoon rainfall increased up to 27% due to cyclonic effect. The shaded region shows significant correlation coefficient with 5% level of significance.

Table – 5 Decade and Tahsil wise rainfall trends in % from 1980-2010						
Tahsil	Decade	JF	MAM	JJAS	OND	TOTAL
Chalisgaon	1980's	30.59	1.81	20.76	6.58	18.57
	1990's	-35.29	-58.37	-6.70	27.85	-4.25
	2010's	4.71	56.56	-14.06	-34.43	-14.31
Bhadgaon	1980's	-38.27	10.49	10.34	-1.90	8.66
	1990's	75.91	-67.21	-1.66	36.55	1.58
	2010's	-37.63	56.72	-8.68	-34.65	-10.23
Pachora	1980's	-52.05	-29.62	16.31	-2.59	12.97
	1990's	36.88	-89.03	-7.28	30.13	-4.86
	2010's	15.18	118.65	-9.03	-27.53	-8.11
Erandol	1980's	39.34	-46.39	-0.76	2.74	-0.90
	1990's	-100.00	-43.40	0.78	35.66	2.53
	2010's	60.66	89.79	-0.02	-38.40	-1.64
Dharangaon	1980's	40.32	-27.92	5.10	13.50	5.44
	1990's	-100.00	-64.94	4.84	-17.60	0.20
	2010's	59.68	92.86	-9.94	4.10	-5.64
Parola	1980's	-10.04	-35.27	14.36	-7.51	11.16
	1990's	19.30	-55.59	-3.98	52.19	0.63
	2010's	-9.26	90.87	-10.38	-44.68	-11.79
Amalner	1980's	64.47	-3.21	9.02	2.73	8.44
	1990's	-29.19	-25.46	5.63	16.42	6.18
	2010's	-35.28	28.67	-14.65	-19.15	-14.62
Jamner	1980's	29.38	3.64	20.37	-17.28	16.29
	1990's	-2.47	-41.35	-4.90	33.26	-2.14
	2010's	-26.91	37.71	-15.47	-15.98	-14.16
Edlabad	1980's	57.11	-20.64	-11.51	28.65	-6.20
	1990's	-65.37	-60.67	5.94	11.13	3.87
	2010's	8.26	81.31	5.57	-39.78	2.33
Total	1980's	16.31	-13.10	10.07	-0.27	8.61
	1990's	-17.53	-56.80	-1.21	26.95	0.28
	2010's	1.22	69.90	-8.86	-26.68	-8.89

Source: Computed by the researcher

In the decade of 2000-2010 monsoon rainfall trend has slightly decreased down to 8.89% annually. At the same time, winter monsoon increases 1.22%. Summer monsoon increase has 69.90% but southwest monsoon decreases down to 8.86% along with northeast monsoon decreasing up to 2.7%. Highest in Dharangaon is 192.88% and lowest in Parola tahsil is 95.05%

(Graph – 5). The monsoon rainfall trend continuous declined during 1980-1990, 1990-2000 and 2000-2010 these decades. In the 1980-1990 decade summer and north east monsoon declined trend but winter and southwest monsoon increased about 16 and 10% comparatively.

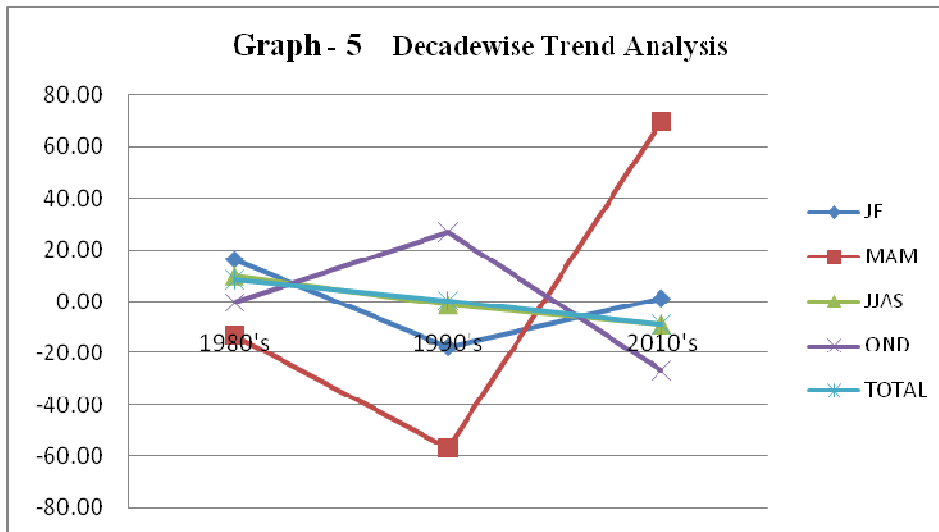


Table – 6 Correlation Matrix of Rainfall Data (1980 to 2010)

	Chalisingaon	Bhadgaon	Pachora	Erandol	Dharangaon	Parola	Amalner	Jamner	Edlabad
Chalisingaon	1.00								
Bhadgaon	0.79	1.00							
Pachora	0.72	0.80	1.00						
Erandol	0.42	0.59	0.53	1.00					
Dharangaon	0.47	0.63	0.63	0.91	1.00				
Parola	0.33	0.39	0.34	0.43	0.62	1.00			
Amalner	0.28	0.39	0.37	0.50	0.74	0.59	1.00		
Jamner	0.36	0.44	0.39	0.23	0.34	0.30	0.33	1.00	
Muktainagar	0.45	0.47	0.47	0.50	0.41	0.08	0.10	0.15	1.00

Source: Computed by the researcher

6. Conclusion: This study investigated rainfall inter-annual analysis in drought-prone areas in Jalgaon district of Maharashtra state. The analysis carried out using data from about 9 rain gauge stations for a period from 1980-2010 for 31 years.

The network considered in this study is more uniformly spaced and temporally homogeneous, which can be used for analyzing the spatial and temporal variability in better way. The present study explored the significant observations about rainfall trends, variation and critical

variability in the study area. It is observed that the annual average rainfall has generally decreased in June and July. But contribution of rainfall in August has generally increased. Though southwest monsoon is the major rain producing season in the study area, other seasons have also significant. The study has proven that the monsoon has been paramount dominant in the southern part of the study area. The monsoon gets stabilized in the west, north and east parts. Also, all the monsoons are paramount dominant at the foothills. The

windward of the Hatti, Ajanta and Satmala ranges and Chandor hills region, which includes Chalisgaon, Pachora, Jamner tahsils, has high intensity of rainfall. On the other hand, northwest, north and northeast leeward of study area experience the high deficits in the rainfall intensity. The annual rainfall variability is lowest in comparison with the monsoon season rainfall variability. The abnormality of rainfall is highest in Dharangaon tahsil and lowest in Parola tahsil.

The annual average monsoon rainfall trend continuously declined. The summer monsoon declined at the same time the northeast monsoon increased. On the other hand, winter and southwest monsoon rainfall decreased. It is also observed that summer monsoon increased and the north east monsoon automatically decreased. Again, southwest and winter monsoons decrease along with the northeast monsoon.

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