International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

Research paper

Climate Change Impact Studies on Rainfall Patterns for Past and Present Century - A Case Study

O. P. Sahu[1], Pitambra Sahu[2] and Pradeep K. Jain[3]
[1]Department of Geology, Govt. Model College, Shahpura Dindori, MP, India
[2]Department of Geography, Awdhesh Pratap Singh University, Rewa MP, India
[3]Departments of Geology, Govt. Maharaja P.G. Collage, Chhatarpur, MP, India
Corresponding author Email: opsahugeocbri@gmail.com

Received: 05/12/2019
Revised: 12/12/2019
Accepted: 18/01/2020

Abstract: In the twentieth century many recent studies show changes in rainfall patterns of India as well as changes in weather conditions. These are due to global climate changes, decrease in rainfall duration and rainfall amount and increase in rainfall intensity. In the present paper an attempt has been made to describe Climate change impact studies on rainfall patterns for the past and present century (1901 to 2013) of Sagar region. The rainfall data for a period from 1901 to 2013 have been collected from the District Land Record Department of Sagar and Indian Meteorological Department, New Delhi. The results of 113 years old historical rainfall records of Sagar region have been computed by statistical and time series analysis techniques. Results are also discussed for the future climate change scenario in rainfall patterns of the study area.

Keywords: Climate Change, Rainfall Pattern, Statistical Parameter and Time Series Analysis

INTRODUCTION

Global climate has changed significantly in the last hundred years. Global mean surface air temperature has increased by 0.74˚C during the last century (IPCC 2007). Increasing temperature, snow cover retreat and changing patterns of rainfall, are among the many consequences which are attributed to climate change. Trend detection in rainfall patterns is one of the interesting research areas in climatology. It is noted that rainfall pattern changes are not globally uniform such as regional variations can be much larger, and considerable spatial and temporal variations may exist between climatically different regions (Yue and Hashino 2003). It is now widely accepted that changes in rainfall patterns can be associated with changes in frequency of rainfall and amount of rainfall per events. Understanding rainfall pattern changes in variability climate change during recent decade have become important under future climate change scenario. To achieve this study using statistical and time series techniques for determination of rainfall

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

variation patterns on regional or local scale.

India is already facing high degree of climate variability and may face additional challenge of climate change. A significant part of the annual variation in India's GDP growth over the past half century is attributable to yearly variations in rainfall. The Himalayan ecosystem, so vital for our water security, is vulnerable to climate change. Moreover, increases in mean sea levels will affect large populations and communities in peninsular and coastal India. It has been noticed that the Gangotri glacier, one of the largest glaciers in the Himalayas, has been retreating since long and more rapidly in recent decades. As the glaciers retreat, they become more fragmented and the smaller glaciers are more sensitive to global warming. As per the Geological Survey of India, glaciers are worldwide in a phase of recession as a natural cyclic process. The accelerated melting which these glaciers are experiencing as a result of the earth's warming may have a profound effect on future water availability. Under these circumstances, it is projected that India may suffer huge losses due to the increased incidence of extreme weather events and additional risks to the livelihoods of people. In recent years, climate change is one of the issues, which have attracted the attention of policy makers and advisors, scholars, directors of several research institutes, among others around the world. In this linkage, variations and trends in rainfall have significant social and economic impacts on agriculture and in turn, people's livelihood in these areas. Consequently, describing changes in the patterns of rainfall (Pennycuick and Norton-Griffiths, 1976) is one of the areas, which have received particular attention by researchers across the world. The amount of rainfall and its distribution over the years largely affect the productivity of agriculture in semi-arid regions of Africa (Sud *et al*., 2010). Thus, appropriate trend analysis of rainfall data is essential for social and economic planning to measure the effects of global warming (Ghosh *et al*., 2009). In recent years, the number of studies on climatic variables has been growing. In the context of India, relatively little is known in statistical terms about the impact of climate change on climate indices including rainfall. Moreover, the few studies (Prins and Loth, 1988; Pennycuick and Norton-Griffiths, 1976) which have been done on rainfall variability have for the most part been focusing on the northern part of the country. Rainfall is one of the most important variables which affect the crop yield differently during various stages of its development. A change in pattern of rainfall is being witnessed by many authors (Kumar *et. al*., 2006; Pant and Hingane, 1988). Accordingly, different scientists have worked out the impact of climate change on crop production (Singh *et. al*., 2009 for apple production, Haris *et al*., 2010 for rice production, etc). In present study have been described Climate Change Scenario on Rainfall Patterns for Past and Present Century using statistical and time series analysis techniques. This study would be useful for impact assessment of rainfall changing patterns on various agro-climatic and socio-economic development studies at regional or local level.

LOCATION OF THE STUDY AREA

The present research area is located at and around Sagar City of Madhya Pradesh. The study area is confined to latitudes 23° 47′ to 23° 51′ N and longitudes 78° 43′ to 78° 47″ E (Survey of India Toposheet No. 55I/9 and 55I/10, scale 1:50,000, Fig.1). Elevation of Sagar city is 594 metres (1,949 ft) above sea-level, and around 180 km. northeast of the state capital, Bhopal. The total area of the city is 49 square kilometres. The area of Sagar

International Journal of Global Science Research
Vol. 7, Issue. 1, April 2020, pp. 1109-1131
Available Online at www.ijgsr.com

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v7.i1.2020.143

Division is 6,375 square kilometres (2,461 sq mi) in the shape of a triangle. It is the sixth largest city in the province of Madhya Pradesh. Its original name 'Saugor' is an amalgamation of two words namely 'SAU' meaning 100 and 'GARH' meaning forts, as there were countless small-forts in this region. With time, the name has changed from 'Saugor' to 'Sagar'.

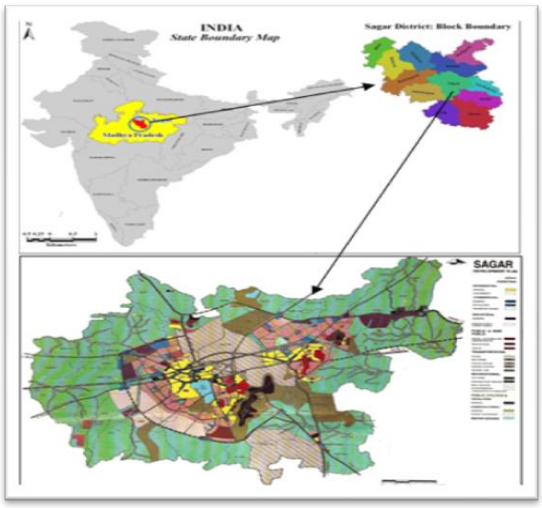

Figure 1.
Location Map of the Study area.

OBJECTIVE OF THE STUDY

To collect the rainfall data during the period of 1901-1913 from IMD and Local Land Record Department Sagar district M.P. and the determine various statistical parameters such as Mean, Median, Mode Coefficient of Dispersion, Co-efficient of Skewness and Time series analysis techniques for Climate Change Impact study on Rainfall Patterns in the region .

MATERIALS AND METHODS

The data used for the study were historical rainfall records and time series data analysis of Sagar City Meteorological Station M.P. during the years of 1901-1913 (Table 1, Figure 1). The rainfall data were collected from Indian Meteorological Department, New Delhi and Land Record Department Sagar district Madhya Pradesh. Various methods of data analysis were employed in the study. Rainfall data were analyzed by using both mathematical and statistical techniques of data analysis using Microsoft Office Excel 2007 and XLSTATE 2014.

The arithmetical procedure involves the determination of average rainfall for a specific period. The departure of rainfall from the average annual rainfall determines the rainfall pattern. The determination of cumulative departure of rainfall provides the information regarding the total departure of rainfall from the mean value over a specific period. The commonly used procedures of statistical analysis as followed by Gupta and Kapoor (1985), Davis (2002) and Sahu (2007) have been followed herein. The computation of statistical parameters includes mean, median, mode, standard deviation, coefficient of dispersion, coefficient of variation and coefficient of skewness. Based on time series analysis (Croxten *et al.*, 1988) for the prediction of future rainfall trend has been visualized.

Table 1. Rainfall data of Sagar City, Madhya Pradesh (1901-2013).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total rainfall
1901	60.91	7.076	14.994	0.456	6.221	31.02	386.488	552.52	118.522	10.002	0.2	1.294	1189.703
1902	8.471	4.507	0	3.06	1.312	27.44	415.506	171.405	235.798	6.502	113.271	1.638	988.91
1903	5.083	0.36	0.437	0	12.431	44.123	257.507	310.944	411.684	62.901	0.2	0.016	1105.686
1904	1.496	10.062	34.586	0	8.374	96.754	514.74	265.555	84.206	14.145	4.283	18.814	1053.015
1905	6.507	7.868	4.769	0.506	1.372	22.617	195.9	249.06	228.155	0.283	0.2	1.632	718.869
1906	0.594	12.655	5.234	0	2.529	139.779	503.707	176.017	410.968	2.232	0.2	2.713	1256.628

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v7.i1.2020.143

1907	7.873	45.292	2.033	9.028	4.484	83.333	217.212	542.797	7.768	0.283	11.205	0.064	931.372
1908	16.117	1.676	10.329	1.753	0.293	42.617	462.909	565.694	71.55	1.796	4.99	1.216	1180.94
1909	5.561	11.992	0.403	10.507	4.544	230.822	259.877	339.837	125.326	0.283	0.2	22.877	1012.229
1910	3.448	0.356	0	1.547	1.441	121.044	191.598	357.331	288.009	13.192	41.448	0.016	1019.43
1911	16.957	0.104	18.533	0.175	0	187.312	185.829	207.445	334.747	22.47	70.308	1.539	1045.419
1912	5.448	14.216	1.19	1.625	0.24	27.15	334.735	335.311	158.171	0.283	88.982	1.84	969.191
1913	0.113	17.775	6.975	0	21.346	177.255	156.587	198.855	49.395	0.373	0.2	20.128	649.002
1914	0.627	3.057	21.37	3.31	13.832	101.802	449.157	224.818	131.934	2.74	1.176	1.711	955.534
1915	7.076	25.713	38.427	11.003	7.392	70.95	272.658	505.833	175.783	49.409	3.317	1.191	1168.752
1916	0.113	21.673	0	1.545	2.834	129.904	239.615	430.341	232.734	86.289	11.771	0.016	1156.835
1917	15.909	35.838	6.714	2.05	29.023	136.457	406.31	457.395	288.248	20.634	0.2	2.64	1401.418
1918	2.292	3.076	0.419	0.162	9.487	167.338	213.998	286.683	111.383	0.397	15.631	6.693	817.559
1919	64.244	4.579	1.23	16.452	14.472	72.479	382.783	812.679	88.338	55.885	16.65	5.412	1535.203
1920	8.142	2.422	3.855	0	25.478	144.568	474.025	170.299	96.691	0.289	0.2	0.016	925.985
1921	17.489	3.798	0	0.022	0	224.942	162.266	385.04	308.143	2.224	0.2	0.016	1104.14
1922	32.601	3.002	0.604	0.222	1.342	159.929	485.322	266.481	252.947	0.705	30.435	12.306	1245.896
1923	5.808	4.018	8.597	1.91	7.461	21.523	559.259	596.506	300.509	24.581	3.1	14.922	1548.194
1924	15.61	1.819	1.357	0.097	3.073	41.248	318.78	391.502	256.31	11.899	2.557	11.212	1055.464
1925	0.113	0.04	0	0	26.44	131.028	605.496	349.382	129.746	7.734	50.351	0.054	1300.384
1926	8.863	2.76	27.896	6.482	28.133	24.657	303.332	528.632	362.326	36.886	0.854	2.373	1333.194
1927	1.937	13.364	20.221	5.894	0.312	75.765	522.275	179.67	117.96	67.359	143.27	17.104	1165.131
1928	7.342	50.441	4.869	3.576	1.889	62.992	502.804	162.903	122.966	40.958	2.777	88.129	1051.646
1929	12.113	8.656	0	6.341	0.015	69.819	545.739	507.011	104.497	5.383	0.2	32.807	1292.581
1930	2.218	5.005	0.297	4.678	1.918	106.355	590.9	219.765	132.081	11.773	7.282	3.653	1085.925
1931	2.686	12.119	1.261	0.165	2.618	48.476	334.209	418.477	447.792	109.197	112.348	0.347	1489.695
1932	0.113	15.392	13.411	4.552	0.755	34.491	770.823	239.948	242.481	16.513	2.344	0.016	1340.839
1933	0.113	6.08	8.079	11.753	18.137	223.921	284.68	301.963	379.819	21.79	1.319	1.32	1258.974
1934	12.069	0.04	8.158	0.142	0	236.232	406.613	646.484	585.553	4.572	55.284	32.963	1988.11
1935	10.797	12.291	0	17.202	3.435	144.23	500.842	388.49	286.231	6.083	1.986	37.317	1408.904
1936	0.704	16.06	10.718	6.089	4.157	200.685	332.52	246.309	295.63	5.474	53.678	7.014	1179.038
1937	0.113	44.535	2.901	11.788	3.327	258.445	389.53	315.164	139.51	42.516	15.076	4.37	1227.275
1938	30.177	1.372	1.221	0.566	10.969	288.446	379.322	271.246	110.319	116.045	0.2	0.016	1209.899
1939	20.239	3.649	6.004	2.366	0	118.616	544.429	282.912	139.204	5.912	0.323	1.08	1124.734
1940	8.326	11.626	7.797	4.013	19.355	100.919	555.998	412.135	136.126	7.512	7.325	15.854	1286.986
1941	22.362	16.706	12.582	0.142	2.404	94.161	218.743	267.348	107.619	0.283	0.2	0.016	742.566
1942	39.172	35.149	1.092	3.709	0.136	127.888	706.805	396.507	196.363	3.488	0.2	16.863	1527.372
1943	47.108	0.206	0.061	7.091	14.896	106.036	391.948	417.678	174.215	37.139	0.654	0.016	1197.048
1944	19.219	28.108	38.047	12.579	0	88.004	787.296	536.861	134.138	32.454	0.285	7.591	1684.582
1945	49.962	0.052	0	11.538	5.241	249.385	568.218	294.945	255.843	7.96	0.2	5.551	1448.895
1946	0.113	8.287	0	12.33	3.513	188.977	374.493	564.762	54.861	27.637	65.638	10.903	1311.514

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v7.i1.2020.143

1947	42.214	18.39	8.496	1.896	0.725	91.742	681.424	611.851	394.372	15.578	2.025	1.504	1870.217
1948	68.757	2.869	1.461	1.85	1.888	157.496	437.71	416.409	203.919	18.363	96.758	0.016	1407.496
1949	0.113	5.151	0.126	0.23	4.724	115.532	322.634	319.531	509.986	73.121	0.2	0.016	1351.364
1950	19.975	6.535	10.716	0.088	1.678	46.955	372.118	425.308	142.846	0.344	0.245	25.824	1052.632
1951	9.099	28.167	8.468	0.866	11.852	71.714	456.749	338.266	253.057	7.526	6.326	0.016	1192.106
1952	0.12	22.906	6.316	1.809	0.945	201.933	394.826	458.565	62.724	0.658	0.2	20.989	1171.991
1953	16.102	2.844	0	2.25	0.638	34.7	432.663	304.083	152.626	10.881	0.2	1.516	958.503
1954	34.566	19.967	8.015	0.015	0.167	82.789	232.885	313.907	436.505	27.777	0.2	0.016	1156.809
1955	28.293	2.555	0.763	0.23	0.991	169.728	248.993	592.986	400.986	82.212	0.2	0.222	1528.159
1956	11.19	2.255	2.577	0.177	5.668	184.631	765.362	432.645	205.851	39.075	69.328	9.192	1727.951
1957	23.291	0.052	23.947	4.843	7.337	82.717	310.531	336.329	196.045	4.665	1.199	2.294	993.25
1958	3.488	2.14	6.557	0.475	0.373	70.201	545.302	378.133	235.648	138.082	6.324	1.426	1388.149
1959	23.767	6.875	0	5.192	29.61	96.843	314.311	631.194	348.704	31.288	2.363	0.016	1490.163
1960	47.897	0.04	9.314	2.131	1.791	72.256	333.608	872.051	63.81	103.411	0.2	1.539	1508.048
1961	35.14	4.411	2.128	1.372	8.297	94.279	422.257	500.845	311.261	133.967	35.448	4.617	1554.022
1962	13.028	18.974	6.284	17.234	3.167	39.37	383.15	704.791	439.935	0.47	3.456	19.68	1649.539
1963	23.334	13.095	3.24	6.865	3.527	106.433	357.849	324.501	381.332	8.951	7.001	4.781	1240.909
1964	0.113	2.271	19.782	0.175	17.374	95.018	316.108	447.282	207.288	2.38	0.2	0.785	1108.776
1965	13.827	2.413	5.965	10.146	1.761	53.767	234.635	218.332	230.592	11.656	0.2	21.901	805.195
1966	2.244	2.183	1.008	0.23	3.898	134.851	319.697	218.905	38.976	0.956	74.028	3.064	800.04
1967	0.749	0.04	34.407	0.45	0.813	67.111	314.373	452.167	228.486	0.371	0.2	103.891	1203.058
1968	15.223	2.756	8.914	0.669	0	93.032	521.19	232.534	76.879	52.11	0.2	1.989	1005.496
1969	2.071	1.369	1.608	0	10.528	19.614	585.505	530.649	156.903	0.283	119.182	0.016	1427.728
1970	31.3	24.67	25.403	0.315	6.011	125.027	193.936	498.676	231.063	6.219	0.2	0.016	1142.836
1971	14.674	3.189	1.228	2.5	9.39	327.662	365.89	326.993	168.097	130.472	0.615	0.016	1350.726
1972	2.609	5.157	0	0.213	2.654	34.29	117.949	572.178	183.465	76.889	26.097	7.263	1028.764
1973	2.201	4.236	0	0.022	4.299	9.186	642.54	575.151	225.534	21.298	0.2	28.261	1512.928
1974	0.113	1.946	0.732	1.331	5.096	97.472	306.524	560.492	50.862	64.345	0.268	0.016	1089.197
1975	8.39	17.553	3.472	0.226	0.145	174.071	306.728	405.606	256.639	32.575	0.2	0.016	1205.621
1976	13.813	0.205	4.333	9.712	9.127	120.512	305.773	475.974	205.592	0.283	65.187	1.675	1212.186
1977	10.485	1.754	5.686	2.351	9.07	341.587	350.273	431.197	193.658	23.267	53.547	5.42	1428.295
1978	8.101	74.316	28.557	7.616	0.537	220.013	314.021	659.979	210.445	2.518	3.118	61.462	1590.683
1979	50.77	27.092	2.637	0.176	20.835	69.258	395.963	246.697	27.442	3.419	35.79	2.347	882.426
1980	0.942	2.767	2.187	0	0.076	230.776	355.917	437.509	51.621	2.862	0.615	32.218	1117.49
1981	4.662	2.499	8.999	0.297	7.806	76.763	189.675	280.452	124.13	1.525	4.711	21.137	722.656
1982	103.079	7.51	5.208	3.166	3.106	60.271	238.663	908.451	179.078	6.692	98.132	4.729	1618.085
1983	10.785	1.12	0.559	2.927	7.442	109.479	467.754	454.717	535.908	63.191	0.2	1.575	1655.657
1984	58.918	30.154	0.32	1.604	3.429	122.069	134.99	421.175	71.642	3.53	0.2	0.016	848.047
1985	16.863	0.202	0.407	8.839	11.044	94.099	413.208	470.269	222.875	122.124	0.2	3.437	1363.567
1986	11.866	35.877	12.537	0	11.973	133.394	301.68	196.159	67.989	18.781	1.094	40.793	832.143

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

1987	21.397	35.186	2.472	0	11.883	53.495	201.448	409.748	172.543	16.755	4.522	23.376	952.825
1988	2.087	2.81	3.056	5.624	0.54	186.227	227.198	243.894	101.571	2.49	1.74	6.967	784.204
1989	3.47	0.04	18.668	0	0.743	96.583	236.442	396.101	62.863	2.589	3.49	15.587	836.576
1990	0.113	23.481	3.125	0.543	16.919	409.203	604.759	537.995	369.784	8.082	0.2	3.892	1978.096
1991	1.944	6.939	12.288	14.162	6.487	105.385	133.255	460.194	50.293	0.298	2.79	11.532	805.567
1992	14.427	7.627	0.811	0.248	22.184	13.134	58.575	266.754	335.619	12.013	7.758	0.016	739.166
1993	1.432	10.558	4.665	0.088	8.133	90.16	170.069	172.488	118.448	19.613	0.2	1.545	597.399
1994	20.423	18.833	19.088	2.728	13.616	275.975	700.516	390.135	104.427	14.944	0.2	0.016	1560.901
1995	36.387	9.949	27.662	5.464	0.854	108.162	311.639	176.964	249.32	14.857	8.976	28.806	979.04
1996	30.571	8.893	7.315	18.144	5.685	75.324	241.47	467.372	113.517	31.127	1.624	0.016	1001.058
1997	4.869	0.04	0.434	2.132	9.901	61.491	316.925	309.224	137.11	49.253	126.933	73.562	1091.874
1998	1.722	3.312	27.318	0.718	2.237	102.482	188.566	416.075	242.516	17.698	71.693	0.016	1074.353
1999	7.288	61.01	0	0	8.589	49.57	398.96	407.212	303.42	71	0.2	0.398	1307.647
2000	1.664	1.743	0.103	0.03	12.774	96.806	664.366	156.155	85.058	0.797	0.306	0.016	1019.818
2001	10.169	1.312	5.656	2.628	24.391	329.28	340.174	202.411	30.111	37.528	4.892	0.016	988.568
2002	3.553	38.599	2.94	1.665	12.189	100.451	83.958	416.884	143.736	19.871	16.528	4.303	844.677
2003	2.2	32.4	0	0	0	67.2	331.3	321.7	341.9	0.2	0	12.5	1109.4
2004	25.6	0	0	5	42	306.8	182	363.6	100.6	35.7	9.4	0	1070.7
2005	11.6	3.2	49.3	3.6	3.3	186.6	1012	213.3	156.6	1.2	0	3.9	1644.6
2006	0	0	68.1	8.1	36.1	73.9	419.4	308.5	115	1.4	9.6	0	1040.1
2007	0	21.6	0.4	1	15.9	106	260.8	216.5	119.5	0	0.2	4.6	746.5
2008	0.1	0	5	7.8	1.2	384	228.4	303.9	86	9.9	0	0	1026.3
2009	3.6	2.9	0.3	1.4	9.5	45.6	266.2	249.8	282.4	113.8	131.4	8.4	1115.3
2010	3.2	1.3	0	0	0	33.8	375.9	255.8	106.4	1.2	3.7	2.2	783.5
2011	0	1.7	0.1	11.1	12.3	484.6	355.3	270.4	156.7	0	0	0	1292.2
2012	26.9	0	0	0.4	3.5	66.6	271.2	432.1	110.6	1	0	0	912.3
2013	0	18.7	25.8	1.6	0	511.5	721.2	539.7	65.6	50	0.4	0	1934.5
TOTAL	1623.236	1255.509	903.629	393.088	837.348	14430.9	42671.17	43636.79	22369.01	2881.895	2065.53	1052.65	**134120.74**
AVERAGE	14.365	11.111	7.997	3.479	7.41	127.707	377.621	386.166	197.956	25.503	18.279	9.315	**1186.909**

Mathematical Method

The mathematical method is most commonly used, which involves calculation of the average rainfall of years or months as shown by the arithmetic mean of the period/years or months. For this a suitable mean is required to show the variability of the rainfall. The mean of a particular distribution is mostly affected by the extreme values and, therefore, it is necessary to calculate the median rainfall in the analysis of arithmetic average. The total monthly and seasonal rainfall data of Sagar region have been recorded (Table-1). The trend of monthly rainfall record for a period of one hundred thirteen years has been exhibited (Fig.-1), whereas the monsoonal, seasonal variations have been demonstrated to observe the nature of rainfall fluctuation pattern (Fig.- 4). The maximum precipitation in the last one hundred thirteen years was recorded as 1988.11 mm during the year of 1934 and minimum rainfall of 597.399 mm was

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

noted in the year of 1993. The average rainfall of the study area has been calculated to be 1186.909 mm. The departure and cumulative departure from the average rainfall of the study areas has been displayed (Table-3, Figs.-3 and 4). The trend of annual departure from the computed value of average annual rainfall (Table- 3, Figs.- 3 and 4) reveals that years showing annual departure more than the average annual rainfall were – 1901, 1906, 1917, 1919, 1922, 1923, 1925, 1926, 1929, 1931, 1932, 1933, 1934, 1935, 1937, 1938, 1940, 1942, 1943, 1944,1945, 1946, 1947, 1948, 1949, 1951, 1955, 1956, 1958, 1959, 1960, 1961, 1962, 1963, 1967, 1969, 1971, 1973, 1975, 1976, 1977, 1978, 1982, 1983, 1985, 1990, 1994, 1999, 2005, 2011 and 2013. Years showing annual departure less than the average annual rainfall were – 1902, 1903, 1904, 1905, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914, 1915,1916, 1918, 1920, 1921, 1924, 1927, 1928, 1930, 1936, 1939, 1941, 1950, 1952, 1953, 1954, 1957, 1964, 1965, 1966, 1968, 1970, 1972, 1974, 1979, 1980, 1981, 1984, 1986, 1987, 1988, 1989, 1991, 1992, 1993, 1995, 1996, 1997, 1998, 2000, 2001, 2002, 2003, 2004, 2006, 2007, 2008, 2009,2010 and 1912.

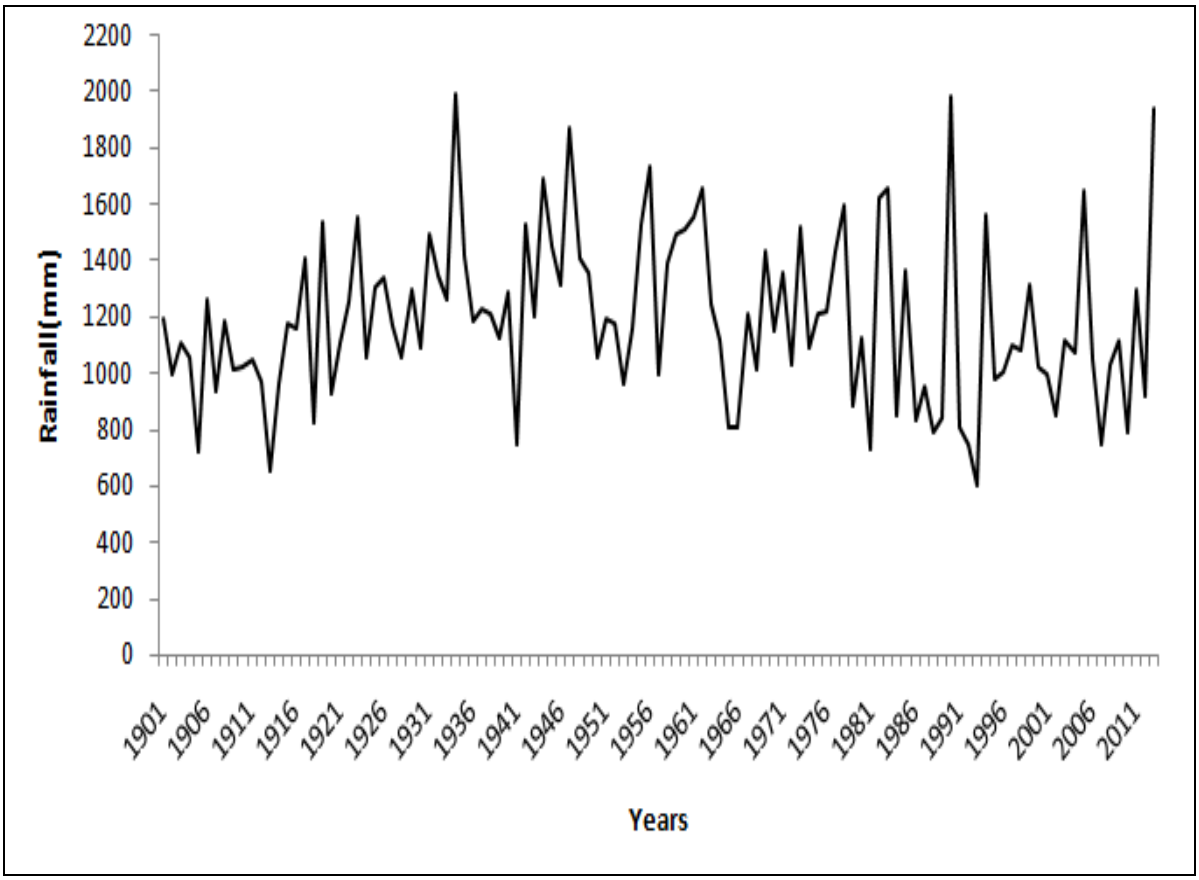

Figure 1. Rainfall data of Sagar City, Madhya Pradesh (1901-2013).

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

Table 2. Time series analysis of rainfall data of Sagar City, Madhya Pradesh (1901 – 2013).

S. No.	Year	x	y	x^2	xy	x^3	x^2y	x^4	$y_c = a + bx$	Error Test
1	1901	-56	1189.703	3136	-66623.368	-175616	3730908.6	9834496	1206.8954	-17.192
2	1902	-55	988.91	3025	-54390.05	-166375	2991452.8	9150625	1206.5385	-217.629
3	1903	-54	1105.686	2916	-59707.044	-157464	3224180.4	8503056	1206.1816	-100.496
4	1904	-53	1053.015	2809	-55809.795	-148877	2957919.1	7890481	1205.8247	-152.81
5	1905	-52	718.869	2704	-37381.188	-140608	1943821.8	7311616	1205.4678	-486.599
6	1906	-51	1256.628	2601	-64088.028	-132651	3268489.4	6765201	1205.1109	51.517
7	1907	-50	931.372	2500	-46568.6	-125000	2328430	6250000	1204.754	-273.382
8	1908	-49	1180.94	2401	-57866.06	-117649	2835436.9	5764801	1204.3971	-23.457
9	1909	-48	1012.229	2304	-48586.992	-110592	2332175.6	5308416	1204.0402	-191.811
10	1910	-47	1019.43	2209	-47913.21	-103823	2251920.9	4879681	1203.6833	-184.253
11	1911	-46	1045.419	2116	-48089.274	-97336	2212106.6	4477456	1203.3264	-157.907
12	1912	-45	969.191	2025	-43613.595	-91125	1962611.8	4100625	1202.9695	-233.779
13	1913	-44	649.002	1936	-28556.088	-85184	1256467.9	3748096	1202.6126	-553.611
14	1914	-43	955.534	1849	-41087.962	-79507	1766782.4	3418801	1202.2557	-246.722
15	1915	-42	1168.752	1764	-49087.584	-74088	2061678.5	3111696	1201.8988	-33.147
16	1916	-41	1156.835	1681	-47430.235	-68921	1944639.6	2825761	1201.5419	-44.707
17	1917	-40	1401.418	1600	-56056.72	-64000	2242268.8	2560000	1201.185	200.233
18	1918	-39	817.559	1521	-31884.801	-59319	1243507.2	2313441	1200.8281	-383.269
19	1919	-38	1535.203	1444	-58337.714	-54872	2216833.1	2085136	1200.4712	334.732
20	1920	-37	925.985	1369	-34261.445	-50653	1267673.5	1874161	1200.1143	-274.129

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

21	1921	-36	1104.14	1296	-39749.04	-46656	1430965.4	1679616	1199.7574	-95.617
22	1922	-35	1245.896	1225	-43606.36	-42875	1526222.6	1500625	1199.4005	46.495
23	1923	-34	1548.194	1156	-52638.596	-39304	1789712.3	1336336	1199.0436	349.15
24	1924	-33	1055.464	1089	-34830.312	-35937	1149400.3	1185921	1198.6867	-143.223
25	1925	-32	1300.384	1024	-41612.288	-32768	1331593.2	1048576	1198.3298	102.054
26	1926	-31	1333.194	961	-41329.014	-29791	1281199.4	923521	1197.9729	135.221
27	1927	-30	1165.131	900	-34953.93	-27000	1048617.9	810000	1197.616	-32.485
28	1928	-29	1051.646	841	-30497.734	-24389	884434.29	707281	1197.2591	-145.613
29	1929	-28	1292.581	784	-36192.268	-21952	1013383.5	614656	1196.9022	95.679
30	1930	-27	1085.925	729	-29319.975	-19683	791639.33	531441	1196.5453	-110.62
31	1931	-26	1489.695	676	-38732.07	-17576	1007033.8	456976	1196.1884	293.507
32	1932	-25	1340.839	625	-33520.975	-15625	838024.38	390625	1195.8315	145.008
33	1933	-24	1258.974	576	-30215.376	-13824	725169.02	331776	1195.4746	63.499
34	1934	-23	1988.11	529	-45726.53	-12167	1051710.2	279841	1195.1177	792.992
35	1935	-22	1408.904	484	-30995.888	-10648	681909.54	234256	1194.7608	214.143
36	1936	-21	1179.038	441	-24759.798	-9261	519955.76	194481	1194.4039	-15.366
37	1937	-20	1227.275	400	-24545.5	-8000	490910	160000	1194.047	33.228
38	1938	-19	1209.899	361	-22988.081	-6859	436773.54	130321	1193.6901	16.209
39	1939	-18	1124.734	324	-20245.212	-5832	364413.82	104976	1193.3332	-68.599
40	1940	-17	1286.986	289	-21878.762	-4913	371938.95	83521	1192.9763	94.01
41	1941	-16	742.566	256	-11881.056	-4096	190096.9	65536	1192.6194	-450.053
42	1942	-15	1527.372	225	-22910.58	-3375	343658.7	50625	1192.2625	335.11
43	1943	-14	1197.048	196	-16758.672	-2744	234621.41	38416	1191.9056	5.142
44	1944	-13	1684.582	169	-21899.566	-2197	284694.36	28561	1191.5487	493.033
45	1945	-12	1448.895	144	-17386.74	-1728	208640.88	20736	1191.1918	257.703
46	1946	-11	1311.514	121	-14426.654	-1331	158693.19	14641	1190.8349	120.679

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v7.i1.2020.143

47	1947	-10	1870.217	100	-18702.17	-1000	187021.7	10000	1190.478	679.739
48	1948	-9	1407.496	81	-12667.464	-729	114007.18	6561	1190.1211	217.375
49	1949	-8	1351.364	64	-10810.912	-512	86487.296	4096	1189.7642	161.6
50	1950	-7	1052.632	49	-7368.424	-343	51578.968	2401	1189.4073	-136.775
51	1951	-6	1192.106	36	-7152.636	-216	42915.816	1296	1189.0504	3.056
52	1952	-5	1171.991	25	-5859.955	-125	29299.775	625	1188.6935	-16.703
53	1953	-4	958.503	16	-3834.012	-64	15336.048	256	1188.3366	-229.834
54	1954	-3	1156.809	9	-3470.427	-27	10411.281	81	1187.9797	-31.171
55	1955	-2	1528.159	4	-3056.318	-8	6112.636	16	1187.6228	340.536
56	1956	-1	1727.951	1	-1727.951	-1	1727.951	1	1187.2659	540.685
57	1957	0	993.25	0	0	0	0	0	1186.909	-193.659
58	1958	1	1388.149	1	1388.149	1	1388.149	1	1186.5521	201.597
59	1959	2	1490.163	4	2980.326	8	5960.652	16	1186.1952	303.968
60	1960	3	1508.048	9	4524.144	27	13572.432	81	1185.8383	322.21
61	1961	4	1554.022	16	6216.088	64	24864.352	256	1185.4814	368.541
62	1962	5	1649.539	25	8247.695	125	41238.475	625	1185.1245	464.415
63	1963	6	1240.909	36	7445.454	216	44672.724	1296	1184.7676	56.141
64	1964	7	1108.776	49	7761.432	343	54330.024	2401	1184.4107	-75.635
65	1965	8	805.195	64	6441.56	512	51532.48	4096	1184.0538	-378.859
66	1966	9	800.04	81	7200.36	729	64803.24	6561	1183.6969	-383.657
67	1967	10	1203.058	100	12030.58	1000	120305.8	10000	1183.34	19.718
68	1968	11	1005.496	121	11060.456	1331	121665.02	14641	1182.9831	-177.487
69	1969	12	1427.728	144	17132.736	1728	205592.83	20736	1182.6262	245.102
70	1970	13	1142.836	169	14856.868	2197	193139.28	28561	1182.2693	-39.433
71	1971	14	1350.726	196	18910.164	2744	264742.3	38416	1181.9124	168.814
72	1972	15	1028.764	225	15431.46	3375	231471.9	50625	1181.5555	-152.792

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v7.i1.2020.143

73	1973	16	1512.928	256	24206.848	4096	387309.57	65536	1181.1986	331.729
74	1974	17	1089.197	289	18516.349	4913	314777.93	83521	1180.8417	-91.645
75	1975	18	1205.621	324	21701.178	5832	390621.2	104976	1180.4848	25.136
76	1976	19	1212.186	361	23031.534	6859	437599.15	130321	1180.1279	32.058
77	1977	20	1428.295	400	28565.9	8000	571318	160000	1179.771	248.524
78	1978	21	1590.683	441	33404.343	9261	701491.2	194481	1179.4141	411.269
79	1979	22	882.426	484	19413.372	10648	427094.18	234256	1179.0572	-296.631
80	1980	23	1117.49	529	25702.27	12167	591152.21	279841	1178.7003	-61.21
81	1981	24	722.656	576	17343.744	13824	416249.86	331776	1178.3434	-455.687
82	1982	25	1618.085	625	40452.125	15625	1011303.1	390625	1177.9865	440.099
83	1983	26	1655.657	676	43047.082	17576	1119224.1	456976	1177.6296	478.027
84	1984	27	848.047	729	22897.269	19683	618226.26	531441	1177.2727	-329.226
85	1985	28	1363.567	784	38179.876	21952	1069036.5	614656	1176.9158	186.651
86	1986	29	832.143	841	24132.147	24389	699832.26	707281	1176.5589	-344.416
87	1987	30	952.825	900	28584.75	27000	857542.5	810000	1176.202	-223.377
88	1988	31	784.204	961	24310.324	29791	753620.04	923521	1175.8451	-391.641
89	1989	32	836.576	1024	26770.432	32768	856653.82	1048576	1175.4882	-338.912
90	1990	33	1978.096	1089	65277.168	35937	2154146.5	1185921	1175.1313	802.965
91	1991	34	805.567	1156	27389.278	39304	931235.45	1336336	1174.7744	-369.207
92	1992	35	739.166	1225	25870.81	42875	905478.35	1500625	1174.4175	-435.252
93	1993	36	597.399	1296	21506.364	46656	774229.1	1679616	1174.0606	-576.662
94	1994	37	1560.901	1369	57753.337	50653	2136873.5	1874161	1173.7037	387.197
95	1995	38	979.04	1444	37203.52	54872	1413733.8	2085136	1173.3468	-194.307
96	1996	39	1001.058	1521	39041.262	59319	1522609.2	2313441	1172.9899	-171.932

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

97	1997	40	1091.874	1600	43674.96	64000	1746998.4	2560000	1172.633	-80.759
98	1998	41	1074.353	1681	44048.473	68921	1805987.4	2825761	1172.2761	-97.923
99	1999	42	1307.647	1764	54921.174	74088	2306689.3	3111696	1171.9192	135.728
100	2000	43	1019.818	1849	43852.174	79507	1885643.5	3418801	1171.5623	-151.744
101	2001	44	988.568	1936	43496.992	85184	1913867.6	3748096	1171.2054	-182.637
102	2002	45	844.677	2025	38010.465	91125	1710470.9	4100625	1170.8485	-326.172
103	2003	46	1109.4	2116	51032.4	97336	2347490.4	4477456	1170.4916	-61.092
104	2004	47	1070.7	2209	50322.9	103823	2365176.3	4879681	1170.1347	-99.435
105	2005	48	1644.6	2304	78940.8	110592	3789158.4	5308416	1169.7778	474.822
106	2006	49	1040.1	2401	50964.9	117649	2497280.1	5764801	1169.4209	-129.321
107	2007	50	746.5	2500	37325	125000	1866250	6250000	1169.064	-422.564
108	2008	51	1026.3	2601	52341.3	132651	2669406.3	6765201	1168.7071	-142.407
109	2009	52	1115.3	2704	57995.6	140608	3015771.2	7311616	1168.3502	-53.05
110	2010	53	783.5	2809	41525.5	148877	2200851.5	7890481	1167.9933	-384.493
111	2011	54	1292.2	2916	69778.8	157464	3768055.2	8503056	1167.6364	124.564
112	2012	55	912.3	3025	50176.5	166375	2759707.5	9150625	1167.2795	-254.98
113	2013	56	1934.5	3136	108332	175616	6066592	9834496	1166.9226	767.577
		$\sum x = 0$	$\sum y = 134120.743$	$\sum x^2 = 120232$	$\sum xy = -42922.307$	$\sum x^3 = 0$	$\sum x^2 y = 133955649.9$	$\sum x^4 = 230244280$	$\sum x^4 = 230244280$	

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

Table 3. Annual rainfall, its departure and cumulative departure from average annual rainfall in Sagar City, Madhya Pradesh (1901-2013).

S. No.	Year	Total rainfall (mm)	Departure from average rainfall	Cumulative Departure from average rainfall
1	1901	1189.703	2.794	2.794
2	1902	988.91	-197.999	-195.205
3	1903	1105.686	-81.223	-276.428
4	1904	1053.015	-133.894	-410.322
5	1905	718.869	-468.040	-878.362
6	1906	1256.628	69.719	-808.643
7	1907	931.372	-255.537	-1064.180
8	1908	1180.94	-5.969	-1070.149
9	1909	1012.229	-174.680	-1244.829
10	1910	1019.43	-167.479	-1412.308
11	1911	1045.419	-141.490	-1553.798
12	1912	969.191	-217.718	-1771.516
13	1913	649.002	-537.907	-2309.423
14	1914	955.534	-231.375	-2540.798
15	1915	1168.752	-18.157	-2558.955
16	1916	1156.835	-30.074	-2589.029
17	1917	1401.418	214.509	-2374.520
18	1918	817.559	-369.350	-2743.870
19	1919	1535.203	348.294	-2395.576
20	1920	925.985	-260.924	-2656.500
21	1921	1104.14	-82.769	-2739.269
22	1922	1245.896	58.987	-2680.282
23	1923	1548.194	361.285	-2318.997
24	1924	1055.464	-131.445	-2450.442
25	1925	1300.384	113.475	-2336.967
26	1926	1333.194	146.285	-2190.682
27	1927	1165.131	-21.778	-2212.460
28	1928	1051.646	-135.263	-2347.723
29	1929	1292.581	105.672	-2242.051
30	1930	1085.925	-100.984	-2343.035
31	1931	1489.695	302.786	-2040.249
32	1932	1340.839	153.930	-1886.319
33	1933	1258.974	72.065	-1814.254
34	1934	1988.11	801.201	-1013.053
35	1935	1408.904	221.995	-791.058
36	1936	1179.038	-7.871	-798.929
37	1937	1227.275	40.366	-758.563
38	1938	1209.899	22.990	-735.573
39	1939	1124.734	-62.175	-797.748

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v7.i1.2020.143

40	1940	1286.986	100.077	-697.671
41	1941	742.566	-444.343	-1142.014
42	1942	1527.372	340.463	-801.551
43	1943	1197.048	10.139	-791.412
44	1944	1684.582	497.673	-293.739
45	1945	1448.895	261.986	-31.753
46	1946	1311.514	124.605	92.852
47	1947	1870.217	683.308	776.160
48	1948	1407.496	220.587	996.747
49	1949	1351.364	164.455	1161.202
50	1950	1052.632	-134.277	1026.925
51	1951	1192.106	5.197	1032.122
52	1952	1171.991	-14.918	1017.204
53	1953	958.503	-228.406	788.798
54	1954	1156.809	-30.100	758.698
55	1955	1528.159	341.250	1099.948
56	1956	1727.951	541.042	1640.990
57	1957	993.25	-193.659	1447.331
58	1958	1388.149	201.240	1648.571
59	1959	1490.163	303.254	1951.825
60	1960	1508.048	321.139	2272.964
61	1961	1554.022	367.113	2640.077
62	1962	1649.539	462.630	3102.707
63	1963	1240.909	54.000	3156.707
64	1964	1108.776	-78.133	3078.574
65	1965	805.195	-381.714	2696.860
66	1966	800.04	-386.869	2309.991
67	1967	1203.058	16.149	2326.140
68	1968	1005.496	-181.413	2144.727
69	1969	1427.728	240.819	2385.546
70	1970	1142.836	-44.073	2341.473
71	1971	1350.726	163.817	2505.290
72	1972	1028.764	-158.145	2347.145
73	1973	1512.928	326.019	2673.164
74	1974	1089.197	-97.712	2575.452
75	1975	1205.621	18.712	2594.164
76	1976	1212.186	25.277	2619.441
77	1977	1428.295	241.386	2860.827
78	1978	1590.683	403.774	3264.601
79	1979	882.426	-304.483	2960.118
80	1980	1117.49	-69.419	2890.699
81	1981	722.656	-464.253	2426.446
82	1982	1618.085	431.176	2857.622

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

83	1983	1655.657	468.748	3326.370
84	1984	848.047	-338.862	2987.508
85	1985	1363.567	176.658	3164.166
86	1986	832.143	-354.766	2809.400
87	1987	952.825	-234.084	2575.316
88	1988	784.204	-402.705	2172.611
89	1989	836.576	-350.333	1822.278
90	1990	1978.096	791.187	2613.465
91	1991	805.567	-381.342	2232.123
92	1992	739.166	-447.743	1784.380
93	1993	597.399	-589.510	1194.870
94	1994	1560.901	373.992	1568.862
95	1995	979.04	-207.869	1360.993
96	1996	1001.058	-185.851	1175.142
97	1997	1091.874	-95.035	1080.107
98	1998	1074.353	-112.556	967.551
99	1999	1307.647	120.738	1088.289
100	2000	1019.818	-167.091	921.198
101	2001	988.568	-198.341	722.857
102	2002	844.677	-342.232	380.625
103	2003	1109.400	-77.509	303.116
104	2004	1070.700	-116.209	186.907
105	2005	1644.600	457.691	644.598
106	2006	1040.100	-146.809	497.789
107	2007	746.500	-440.409	57.380
108	2008	1026.300	-160.609	-103.229
109	2009	1115.300	-71.609	-174.838
110	2010	783.500	-403.409	-578.247
111	2011	1292.200	105.291	-472.956
112	2012	912.300	-274.609	-747.565
113	2013	1934.500	747.591	0.026
TOTAL		134120.743	0.026	
AVERAGE		1186.909		

International Journal of Global Science Research
Vol. 7, Issue. 1, April 2020, pp. 1109-1131
Available Online at www.ijgsr.com

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v7.i1.2020.143

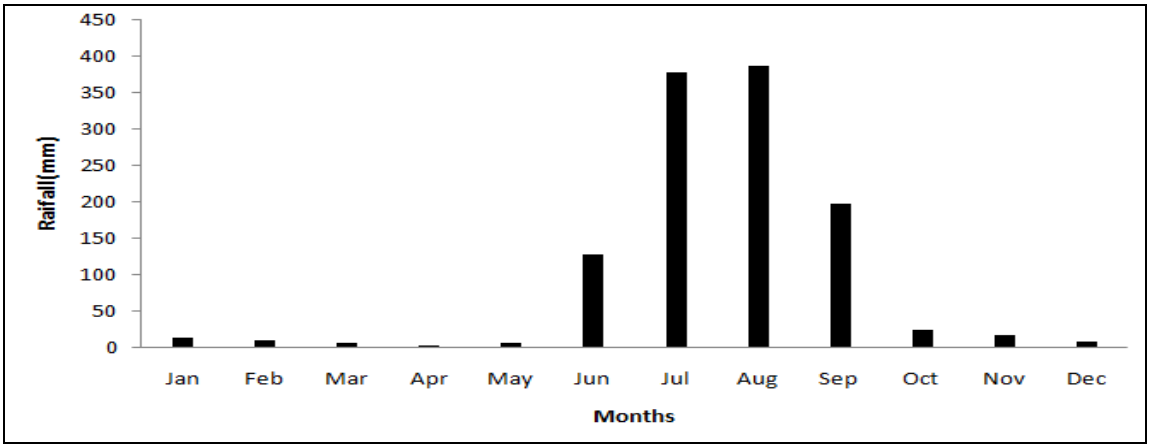

Figure 2. Mean Monthly Rainfall data of Sagar City, Madhya Pradesh (1901-2013).

Statistical Method

The statistical method employed for the analysis of rainfall data of study area for the period 1901 to 2013, includes determinations of central tendencies (mean, median and mode), standard deviation, coefficient of dispersion, coefficient of variation, coefficient of skewness, and time series analysis (Table-5). The procedure of determination of statistical parameters is described below (Table- 6).

Time Series Analysis:

The time series analysis generates valuable information regarding the trend of a series of observations. It helps to measure the deviation from the trend and also provides information pertaining to the nature of trend. This analysis is used as a tool to forecast the future behaviour of the trend. The method of least square fit of straight line has been used for performing the trend analysis of the behaviour of annual rainfall. The straight-line equation can be represented as

Where

$$y_c = a + bx \qquad \text{----- (I)}$$

y_c = Trend value of dependent variable

x = Independent variable

a and b = unknown parameter

To establish a best fit straight line the values of 'a' and 'b' must be determined from the observed data. Simultaneous solving of two normal equations does this.

$$\sum y = Na + b\sum x \qquad \text{----- (II)}$$

$$\sum xy = a\sum x + b\sum x^2 \qquad \text{----- (III)}$$

The values of the various elements in the above equations have been determined by considering y as variable (annual rainfall) and x as constant (year). The determinations were made as per the procedure described below.

N = 113, $\sum x = 0$ $\sum y = 134120.743$

$\sum x^2 = 120232$ $\sum xy = -42922.307$

Substituting these valued in normal equation (II) & (III), two equations (IV) & (V) in terms of a and b are developed

134120743 = 113a+ 0 ------ (IV)

-42922307 = 0+ b120232 ------ (V)

Solving equations (IV) & (V) the values of 'a' & 'b' are obtained as 1186909.23 and -356.99 respectively. Hence a equation of straight line is developed, which can be written as

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

$$y_c = 1186909.23 - 356.99x \quad \text{------ (VI)}$$

With the help of equation (VI) the trend values have been calculated (Table- 7). The future forecast of rainfall amount for period of ten years from 2014 to 2023 has been made.

RESULT AND DISCUSSION

Monthly rainfall trends for Sagar region over the last one hundred thirteen years are generally during the months of January-March and August-October are shows significantly decreasing trends of the area. Only one significant increasing trend appears in the area towards June-August (Figure- 1).

The average rainfall of the Sagar City has been calculated and found to be 1186.909 mm. The departure and cumulative departure from the average rainfall of the area under investigation is given in Table 3. The graph (Fig.-4) showing the departure from average rainfall shows that during the year of. 1901, 1906, 1917, 1919, 1922, 1923, 1925, 1926, 1929, 1931, 1932, 1933, 1934, 1935, 1937, 1938, 1940, 1942, 1943, 1944,1945, 1946, 1947, 1948, 1949, 1951, 1955, 1956, 1958, 1959, 1960, 1961, 1962, 1963, 1967, 1969, 1971, 1973, 1975, 1976, 1977, 1978, 1982, 1983, 1985, 1990, 1994, 1999, 2005, 2011 and 2013 more than the average rainfall. Hence, these years were favourable for ground water recharge of the area. The graph (Fig.- 4) showing departure from average annual rainfall less than were –1902, 1903, 1904, 1905, 1907, 1908, 1909, 1910, 1911, 1912, 1913, 1914, 1915,1916, 1918, 1920, 1921, 1924, 1927, 1928, 1930, 1936, 1939, 1941, 1950, 1952, 1953, 1954, 1957, 1964, 1965, 1966, 1968, 1970, 1972, 1974, 1979, 1980, 1981, 1984, 1986, 1987, 1988, 1989, 1991, 1992, 1993, 1995, 1996, 1997, 1998, 2000, 2001, 2002, 2003, 2004, 2006, 2007, 2008, 2009,2010 and 1912. Hence, these years were not favourable for ground water recharge of the area.

These peaks are indicative of maximum rainfall during the corresponding periods and point out sufficient infiltration of water due to maximum rainfall. Statistical analysis of the present rainfall data reveals that the mean rainfall of the area is 1192.920 mm. The computed value of mode 1104.15mm indicates ideal rainfall for the area. The calculated value of Standard Deviation reveals that deviation of rainfall is of 297.397 mm over a period of one hundred thirteen years. The coefficient of variation indicates that the amount of rainfall varies up to 24.930. The coefficient of Skewness has been noted as 0.29848, which indicates negative trend.

In some, the findings agree with work in other semi-arid regions (Romero *et. al*., 1998, Cook *et. al*., 2004; Reason and Mulenga, 1999), which highlight annual variability of rainfall. Although annual rainfall variations would be considered High or Low in some climate regions, such variations could mean the difference between a good harvest and complete crop failure in semi-arid environments with traditional rain-fed agriculture in area There is much interest in using seasonal to inter annual climate forecasts to help agriculture and other sectors compensate for these variations, but the interactions between the complexities of policy (Chipanshi and Ringrose, 2001) and of local rainfall responses to El-Nino-Southern Oscillation events and other large-scale climate forcing (Nicholson and Grist, 2001).

Climate change Impact study rainfall patterns is concerned with the analysis of any possible factor of rainfall patterns, unfavourable or favourable caused introduced by the drought and flood condition(± 1) observed departure from average rainfall of the study area (Figure-4 & Table-3). The rainfall is one of the

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

most important meteorological parameter that acts as a main source for the recharge of ground water system besides other Climate change impacts. The variation analysis of rainfall data of Sagar region reveals a fairly good range of variation indicating the positive trend before 1946-2007 & 2013 and negative trend from1901- 1945 and 2007-2012 onwards that is resulting into depletion of ground water levels. The present trend of over exploitation due to population growth, industrialization, irrigation and lesser rainfall than the annual average value are affecting the recharge of ground water levels, which are depleting at an alarming rate. The depletion of ground water levels may be assigned to seasonal variations in the static ground water levels, which are influenced by infiltration of rainwater and extraction of ground water (Sahu and Dev 2007). The implementation of an appropriate strategy for rainwater harvesting will generate the possibilities of increase in the amount and intensities of rainfall that in turn, will improve the augmentation phenomena of ground water reservoir. The control over depleting trend of ground water level will provide remedy of sustained water supply to the inhabitants of Sagarregion.

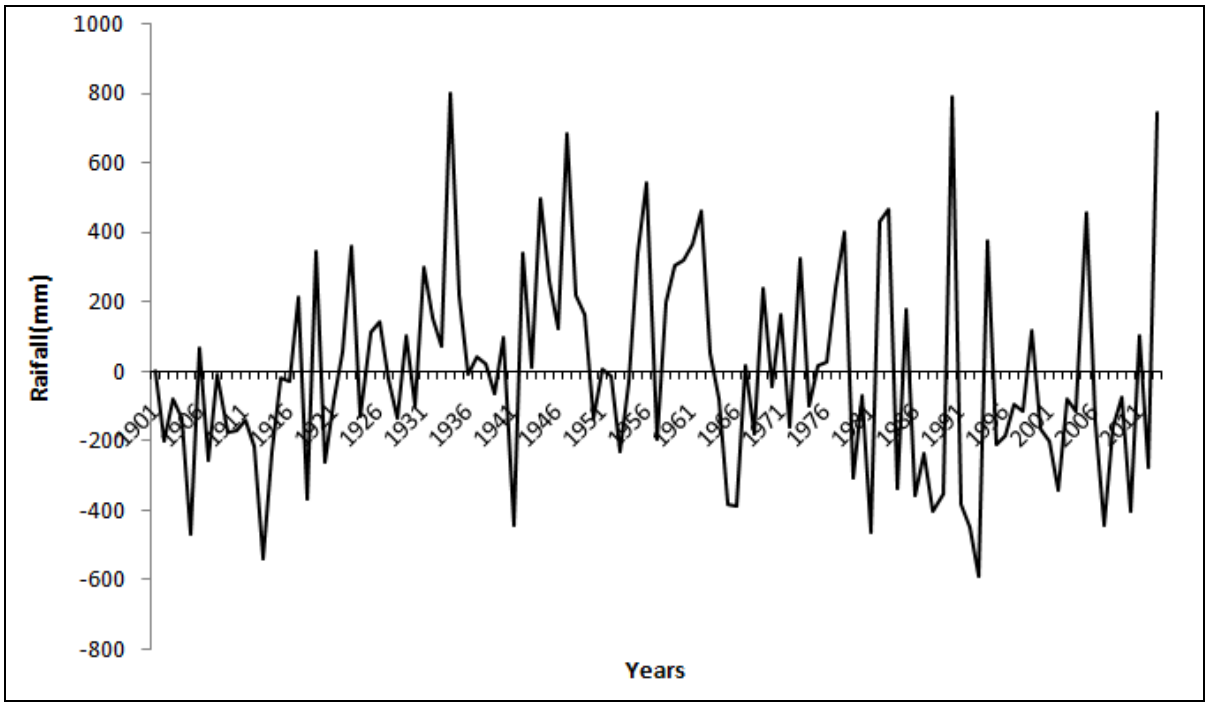

Figure 3. Departure from average Rainfall data of Sagar City, Madhya Pradesh (1901-2013).

International Journal of Global Science Research
Vol. 7, Issue. 1, April 2020, pp. 1109-1131
Available Online at www.ijgsr.com

ISSN: 2348-8344 (Online)
DOI: 10.26540/ijgsr.v7.i1.2020.143

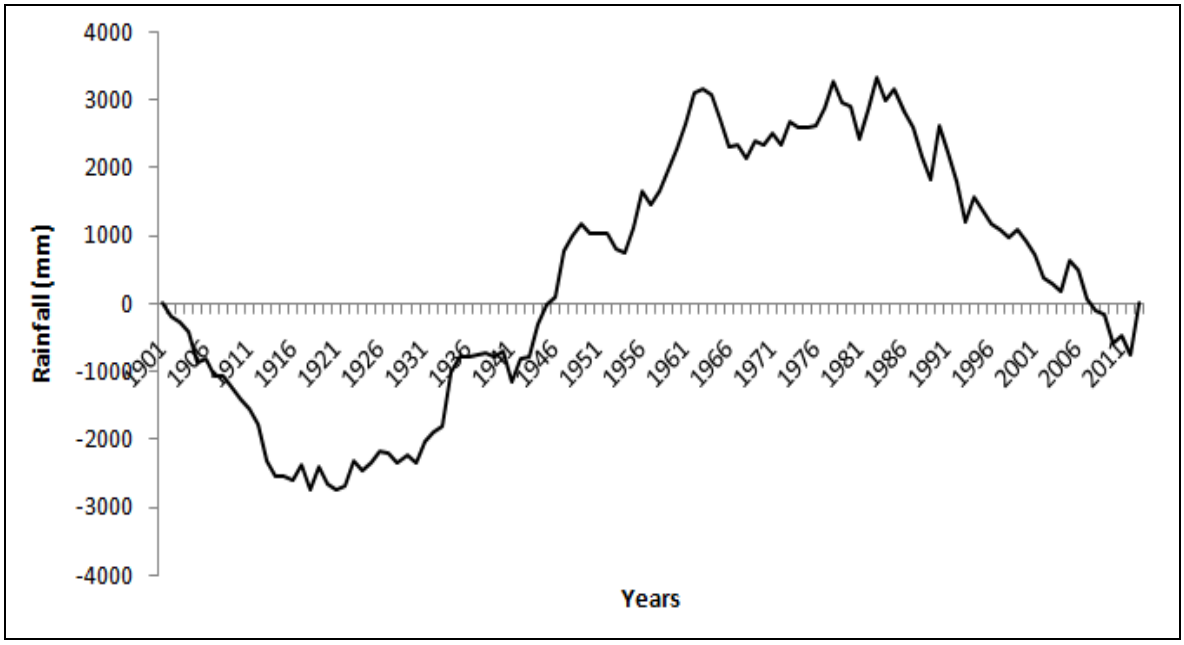

Figure 4. Departure from average Rainfall data of Sagar City, Madhya Pradesh (1901-2013).

Table 4. Computed average monthly and seasonal rainfall of Sagar City, Madhya Pradesh (1901-2013).

S. No.	Season	Months	Mean monthly rainfall (mm)	Average seasonal rainfall (mm)
1	Monsoon	July	377.621	246.811
		August	386.166	
		September	197.956	
		October	25.503	
2	Winter	November	18.279	13.267
		December	9.315	
		January	14.365	
		February	11.111	
3	Summer	March	7.997	36.648
		April	3.479	
		May	7.41	
		June	127.707	
Total				

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

Table 5. Statistical parameter determination of rainfall of Sagar City, Madhya Pradesh (1901-2013).

S. No.	Class Interval	Mid Value (X)	Frequency (f)	$u=\frac{x-1200}{200}$	u^2	fu	fu^2	C. F.
1	500-700	600	2	-3	9	-6	18	2
2	700-900	800	16	-2	4	-32	64	18
3	900-1100	1000	29	-1	1	-29	29	47
4	1100-1300	**1200**	30	0	0	0	0	77
5	1300-1500	1400	17	1	1	17	17	94
6	1500-1700	1600	14	2	4	28	56	108
7	1700-1900	1800	2	3	9	6	18	110
8	1900-2100	2000	3	4	16	12	48	113
Total		$\sum x$ =10400	$\sum f = 113$	$\sum u = 0$	$\sum u^2 = 28$	$\sum fu = -4$	$\sum fu^2 = 250$	

Table 6. Computation of statistical parameters of rainfall data of the Sagar City, Madhya Pradesh (1901-2013).

S. No.	Statistical Parameter	Formula	Computed Value
1.	Mean	$M = A + \frac{\sum fu}{N} \times i$	1192.920
2.	Median	$M_d = l + \frac{\frac{1}{2}N - C.F.}{f} \times i$	1163.33
3.	Mode	$M_0 = 3M_d - 2M$	1104.15
4.	Standard Deviation	$\sigma = i\sqrt{\left\{\frac{\sum fu^2}{N} - \left(\frac{\sum fu}{N}\right)^2\right\}}$	297.397
5.	Coefficient of Dispersion	Standard Deviation/ Mean	0.24930
6.	Coefficient of Variation	100 × (Standard Deviation / Mean)	24.930
7.	Coefficient of Skewness	(Mean-Mode) / Standard Deviation	0.29848

International Journal of Global Science Research **ISSN: 2348-8344 (Online)**
Vol. 7, Issue. 1, April 2020, pp. 1109-1131 **DOI: 10.26540/ijgsr.v7.i1.2020.143**
***Available Online* at** www.ijgsr.com

Table 7. Determination of expected future trend of rainfall in Sagar City, Madhya Pradesh (2014-2023).

S. No.	Year	Procedure of determinates	Expected future trend
1	2014	1186.909-0.3569 (57)	1166.5657
2	2015	1186.909-0.3569 (58)	1166.2088
3	2016	1186.909-0.3569 (59)	1165.8519
4	2017	1186.909-0.3569 (60)	1165.495
5	2018	1186.909-0.3569 (61)	1165.1381
6	2019	1186.909-0.3569 (62)	1164.7812
7	2020	1186.909-0.3569 (63)	1164.4243
8	2021	1186.909-0.3569 (64)	1164.0674
9	2022	1186.909-0.3569 (65)	1163.7105
10	2023	1186.909-0.3569 (66)	1163.3536

CONCLUSION

The rainfall data analysis of Sagar region for a period of 113 years from 1901 to 2013 reveals that variation in the amount and frequency points out a negative trend of rainfall in future as well as. These results suggest that climate change is already affecting Sagar region through decrease in rainfall, begging an important question concerning adaptation: what policies can help the country's semiarid region farmers/Aam Public adapt to climate change? Government has an important role to play. It could increase support for applied research in semiarid region and also support for education in rural areas, support higher-educational opportunities for rural youths and young adults so that they can learn about the latest techniques of semiarid farming technologies, as well as climate change. Although researchers, farmers and Aam Public respond creatively and adaptively to environmental change, to continue to do so under climate change impact they will need the support of government and make possible adaptation. One way that government can enhance the traditional methods for cropping with drought and cover the way for climate change adaptation is to provide farmers with advanced climate and weather information. The rainfall forecasting should be started with monthly, weakly seasonal and daily during critical periods. As a contribution to understand rainfall variability in semiarid region and to place that understanding in the context of climate change, this paper explored rainfall variability and trends study in Sagar area. These results have important policy implications for the government to help its semiarid region Aam Public/ farmers adapt to the changing climate. Authors have been suggested Aam Public apply rainwater harvesting techniques that will provide remedial solution to the prevailing problem of shortage of water supply in Sagar region. The augmentation of ground water recharge by increasing the rainwater harvesting and implementation of scheme for plantation of forest and conservation of rainwater by construction of artificial structures would help to provide the possible solution of demand of water supply.

ACKNOWLEDGEMENT

The appreciation is expressed to Mr. T. T. Thomas National Institute of Hydrology in Sagar Unit for providing Hydro-meteorological data of the Study area. Authors are also thankful to Head of the Department of Applied Geology, Dr. Harisingh Gour University, Sagar Madhya Pradesh, India.

REFERENCES

IPCC (2007) "Climate change 2007, The Physical Science Basis", contribution of working group I to IV assessment report of IPCC.

Yue S and Hashino M (2003) Long term trends of annual and monthly precipitation in Japan; J. Am. Water. Resour. 39(3) 587–596. *http://www.xlstat.com/*

Pennycuick L., and Norton Griffiths M. (1976) Fluctuations in the rainfall of the Serengeti ecosystem, Tanzania, Biogeog. 3:125-40.

Sud Y.C., E.M. Wilcox, K. -M. Lau, G.K. Walker, X. -H. Liu, A. Nenes, D. Lee, K.-M. Kim, Y. Zhou, and P.S. Bhattacharjee (2010) Sensitivity of Boreal-Summer Circulation and Precipitation to Atmospheric Aerosols in Selected Regions, Part I: Africa and India *Annales Geophysicae, 3989-4007, 27.*

Royston M.G., (1978) "Environmental impact assessment. In: Managing the environment", Indian Environmental Society, New Delhi. 5-22.

Ghosh, Subimal, Luniya, Vishal and Gupta, Anant, (2009) Trend analysis of Indian summer monsoon rainfall at different spatial scales ATMOSPHERIC SCIENCE LETTERS Atmos. Sci. Let. 10: 285–290 (2009) Published online 16 October 2009 in Wile Inter Science (www.interscience.wiley.com) DOI:10.1002/asl.235.

Prins H. H. T. and Loth P. E. (1988) Rainfall Patterns as Background to Plant Phenology in Northern Tanzania, Journal of Biogeography, Vol. 15, No. 3 (May, 1988), pp. 451-463.

Kumar, K. Krishna Rajagopalan, Balaji, Hoerling, Martin Bates, Gary, Cane Mark, (2006) Unraveling the Mystery of Indian Monsoon Failure During El Niño, Science: Vol. 314 no. 5796 pp. 115-119 DOI: 10.1126/science.1131152.

Pant G. B. and Hingane L. S. (2006) "Climate changes in and around Rajasthan desert during 20th century",J. of Climatol., 8, 391-401 DOI: 10.1002/joc.3370080406.

Singh M., Kumar J. and Bhardwaj S. S., (2009)"Rainfall probability during dormant and growing seasons of apple in Himanchal Pradesh" J. of Agromet., 11, 1, 47-50.

Haris A. A., Biswas S. and Chhabra V., (2010) "Climate change impacts on productivity of rice (Oryza sativa) in Bihar", Indian J. Agro., 55, 4, 295-298.

Gupta S.C. and Kapoor V.K.,(1985) "Fundamental of Mathematical Statistics", Sultan Chand and Sons, New Delhi, 1100 p.

Davis J. C., (2002) "Statistic and Data Analysis in Geology", John Wiley and Sons, New York, 638 p.

Sahu Om Prakash (2007) Quantitative and Qualitative Investigation of shallow Hydro-geologgical regime of Nimani river basin, Chhatarpur District Madhya Pradesh. Unpublished M.Phil thesis School of studies of Earth Sciences Vikram University Ujjain, Madhya Pradesh Pp 94.

Croxten F. E., Cowden D. J. and Klein S., (1988) "Applied General Statistics", Prentice-Hall India, Pvt.Ltd., New Delhi, p754.

Romero R., Guijarro J. A. and Alonso S. (1998). A 30-year (1964–1993) daily rainfall data base for the Spanish Mediterranean regions: first exploratory study, International Journal of Climatology, 18, 299–316.

Cook C., Reason C. J. C. and Hewitson B. C. (2004) Wet and dry spells within particularly wet and dry summers in the

South African summer rainfall region. Climate Research, 26, 17–31.

Reason C.J.C. and Mulenga H.M.(1999) Relationships between South African rainfall and SST anomalies in the south-west Indian Ocean. International, Journal of Climatology, 19, 1651-1673

Chipanshi A.C., and Ringrose S. (2001) Reflections on the 1997/98 El Nin˜o phenomenon in Botswana. Weather, 56(1), 11–16, 21–24.

Sahu Om Prakash and Dev Pramendra. (2007) Role of rainwater phenomena in recharge of groundwater resource in Chhatarpur area, Madhya Pradesh, Groundwater National Seminar on agriculture and Development and rural drinking water , eds. Singh S., and Singh R.N., CGWB, Bhopal, Pp.364-371.