E-ISSN: 2618-0618
P-ISSN: 2618-060X

NAAS Rating (2025): 5.20
www.agronomyjournals.com
2025; 8(9): 1071-1076
Received: 07-06-2025
Accepted: 10-07-2025

Sandeep Kumar
M. Sc. Research Scholar, Department of Agricultural Meteorology, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

JL Chaudhary
Senior Scientist, Department of Agricultural Meteorology, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Anil Kumar Verma
HOD, Department of Agricultural Meteorology, IGKV, Raipur, Chhattisgarh, India

VC Ratre
Assistant Professor, Department of Agricultural Meteorology, IGKV, Raipur, Chhattisgarh, India

Sandhya Kumari
M. Sc. Research Scholar, Department of Agricultural Meteorology, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Shubhangi Singh
M. Sc. Research Scholar, Department of Agricultural Meteorology, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Bhumika Chandrakar
Field Assistant, Department of Agricultural Meteorology, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Sandeep Kumar
M. Sc. Research Scholar, Department of Agricultural Meteorology, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Effect of El Niño and La Niña on seasonal and annual rainfall in different districts of Chhattisgarh state

Sandeep Kumar, JL Chaudhary, Anil Kumar Verma, VC Ratre, Sandhya Kumari, Shubhangi Singh and Bhumika Chandrakar

DOI: https://www.doi.org/10.33545/2618060X.2025.v8.i9o.3897

Abstract
The present investigation was carried out to study the occurrence and frequency of El-Niño and La-Niña events during 1951-2023 and study the effect of El Niño and La Niña events on rainfall during the period of 1960-2023 at Department of Agricultural Meteorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh). During this long period 1951-2023,11 weak El Niño events, 7 strong El Niño events, 6 moderate El Niño events, 3 very strong El Niño events and 12 week La Niña events, 6 moderate La Niña events and 7 strong La Niña events were found out of 73 years. The average annual and S-W monsoon season rainfall during El Niño years was found to be affected and both negative and positive deviation in rainfall were found. The most of the districts observed negative deviation in rainfall. During La Niña years, annual and S-W monsoon season rainfall, both positive and negative deviation in rainfall were found. Most of the districts observed positive deviation in rainfall.

Keywords: El Niño and La Niña, rainfall and foodgrain production

Introduction
The term El Niño refers to the large-scale ocean-atmosphere climate phenomenon linked to a periodic warming in sea-surface temperatures across the central and east central equatorial Pacific (between approximately the dateline and120°W). The inter-annual variability of seasonal precipitation over India is influenced by El Niño-Southern Oscillation (ENSO) phenomenon. The ENSO is negatively El Niño episodes on crop production or productivity at district level (Rao *et al.*, 2011 and Patel *et al.*, 2014) [5, 4].

La Niña is a climatological phenomenon akin to El Niño, but with opposite tendencies in the tropical Pacific Ocean and atmosphere. La Niña is characterized by stronger than normal trade winds and colder than normal tropical Pacific Sea surface temperatures. It is also characterized by unusually high surface atmospheric pressure in the eastern tropical Pacific and low surface pressure in the western tropical Pacific in association with the Southern Oscillation. The cooling phase (La Niña episodes) is also termed as anti ENSO period. These signals resulted in ecological/economical disasters like heavy rains and floods in Pacific Coast of South America (Nicolls, 1991) [3].

La Niña's effects on global weather are roughly opposite to those of El Niño. La Niña is the reverse of El Niño event and is triggered due to alteration of Sea Surface Temperature (SST) in Pacific Ocean. The La Niña cycle is a complex interaction between random atmospheric phenomenon and oceanic processes. In the La Niña event the trade winds push warm water to ward west and cause it to accumulate in the western Pacific. El Niño and La Niña Years and intensities have been shown in Table-1.

Table 1: El Niño and La Niña Years and Intensities Based on Oceanic Niño Index (ONI)

	El	Niño -27			La Niña -25	
Weak -11	**Moderate-7**	**Strong -6**	**Very Strong -3**	**Weak -12**	**Moderate-6**	**Strong -7**
1952-53	1951-52	1957-58	1982-83	1954-55	1955-56	1973-74
1953-54	1963-64	1965-66	1997-98	1964-65	1970-71	1975-76
1958-59	1968-69	1972-73	2015-16	1971-72	1995-96	1988-89
1969-70	1986-87	1987-88		1974-75	2011-12	1998-99
1976-77	1994-95	1991-92		1983-84	2020-21	1999-00
1977-78	2002-03	2023-24		1984-85	2021-22	2007-08
1979-80	2009-10			2001-02		2010-11
2004-05				2005-06		
2006-07				2008-09		
2014-15				2016-17		
2018-19				2017-18		
				2022-23		

Methodology

Long term district wise (station wise) daily rainfall data for the period (1960-2023) were collected from the Department of Agricultural Meteorology, College of Agriculture Raipur (Chhattisgarh). El Niñoand La-NiñaYears and Intensities (Based on Oceanic Nino Index (ONI) data for the period 1951-2023 were downloaded from the website of Golden gate weather services 2023. (https://ggweather.com/enso/oni.htm). The mean and per cent change for both seasonal as well as annual rainfall was calculated for all districts of Chhattisgarh in Excel.

Normal rainfall (Mean)

It is average of long-term rainfall in a region.

$$\text{Normal rainfall (Mean)} = \frac{\text{Total rainfall of all years}}{\text{Number of years}}$$

ENSO and rainfall

The percentage change in seasonal rainfall and annual rainfall during the weak, moderate, strong and very strong El Niño years as well as the weak, moderate and strong La Niña years were compared to normal rainfall was also computed for the different districts of Chhattisgarh.

$$\text{\% Change for seasonal rainfall} = \frac{\text{(Seasonal rainfall during El Niño/ La Niña year - average seasonal rainfall)}}{\text{Average seasonal rainfall}} \times 100$$

$$\text{\% Change for annual rainfall} = \frac{\text{(Annual rainfall during El Niño/ La Niña year - average annual rainfall)}}{\text{Average annual rainfall}} \times 100$$

The per cent change in rainfall (both seasonal and annual) was individually calculated for all the districts of Chhattisgarh state.

Result and discussion

Characteristics of the El Niño phenomena in terms of span, duration, intensity and impact

El Niño and La Niña generally last between 7 to 18 months. In the northern hemisphere, they develop during the winter season and therefore they take extensions often to about two calendar years. It is noticeable that El Niño events during the last 74 years of the mid-twentieth century to present years occurred in 27 calendar years while La Niña happened during the same period in 25 calendar years. The duration varies from one event to another. In the last El Niño event, the years 2023–24 continued for 11 months. One month, from July 2023 to May 2024 and El Niño events period for the 2018–19 continued for 9 months, starting from September 2018 to May 2019.

Generally, El Niño and La Niña occur every 3-4 years. El Niño is more frequent than La Nina. During the year 1951-2023 we observed four different categories of occurrences (weak, moderate, strong and very strong) for El Niño events (Table 2). Total 11 weak El Niño events, 7 strong El Niño events, 6 moderate El Niño events and 3 very strong El Niño events were observed. Weak El Niño events are more frequently occurring El Niño events followed by moderate El Niño years. The El Niño events adversely affect the Indian and Chhattisgarh monsoon rainfall and negatively impacts are usually seen in food grain production.

El Niño and La Niña events generally last between 5-19 months. In the northern hemisphere, they develop during the winter season and therefore they take extensions often to about two calendar years. It is noticeable that El Niño events during the last fift y years of the twentieth century occurred in 19 calendar years while La Niña happened during the same period in 15 calendar years. Radi (2004) [6] also reported similar results.

Table 2: Beginning of events, temperature deviation degrees, categories and duration of the El Niño phenomenon during the period between 1951-2023

Years	The period of month	Temp. deviation degrees	Categories	El Niño start	El Niño end
1951-52	10	0.5 to 1.2	Moderate	May-51	Feb-52
1952-54	15	0.5 to 0.8	Weak	Jan-53	Mar-43
1957-58	14	1.1 to 1.8	Strong	Mar-57	Apr-58
1958-59	14	0.5 to 0.6	Weak	Mar-58	Apr-59
1963-64	11	0.9 to 1.4	Moderate	May-63	Mar-64
1965-66	12	0.5 to 2.0	Strong	Jun-65	May-66
1968-69	6	0.5 to 1.1	Moderate	Oct-68	Mar-69
1969-70	12	0.5 to 0.9	Weak	Mar-69	Feb-70

1972-73	11	0.6 to 2.1	Strong	Apr-72	Feb-73
1976-77	8	0.6 to 0.9	Weak	Aug-76	Mar-77
1977-78	7	0.5 to 0.8	Weak	Aug-77	Feb-78
1979-80	7	0.5 to 0.6	Weak	Sep-79	Mar-80
1982-83	16	0.7 to 2.2	Very strong	Ape-82	Jul-83
1986-87	11	0.7 to 1.2	Moderate	Aug-86	May-87
1987-88	10	1.0 to 1.7	Strong	Jun-87	Mar-88
1991-92	16	0.6 to 1.7	Strong	Apr-91	Jul-92
1994-95	9	0.5 to 1.1	Moderate	Aug-94	Apr-95
1997-98	15	0.8 to 2.4	Very strong	Apr-97	Jun-98
2002-03	11	0.6 to 1.3	Moderate	02-May	03-Mar
2004-05	10	0.5 to 0.7	Weak	04-Jun	05-Mar
2006-07	7	0.5 to 0.9	Weak	06-Aug	07-Feb
2009-10	10	0.6 to 1.6	Moderate	09-Jul	10-Apr
2014-15	10	0.5 to 0.9	Weak	14-Sep	15-Jun
2015-16	11	1.0 to 2.6	Very strong	15-Jul	16-May
2018-19	9	0.5 to 0.8	Weak	18-Sep	19-May
2023-24	11	0.7 to 1.9	Strong	23-Jul	24-May

Characteristics of the La Niña phenomena in terms of span, duration, intensity and impact

During the year 1951-23 we observed three different categories of occurrence (weak, moderate and strong) of La Niña events (Fig. 1, Table 3). There are 12 week La Niña events, 6 moderate La Niña events and 7 strong La Niña events. Weak La Niña events are more frequently occurring La Niña events than other La Niña events followed by strong La Niña events. The La Niña events positively affect the Indian and Chhattisgarh monsoon rainfall and these positively impacts are usually seen in Indian food grain production.

Table 3: Beginning of events, temperature deviation degree, categories and duration of the La Niña phenomenon during the period between 1951-2023

Years	The period of month	Temp. deviation degrees	Categories	La Niña start	La Niña end
1954-55	18	-0.5 to -0.8	Weak	Apr-54	Sep-55
1955-56	13	-0.8 to -1.7	Moderate	Oct-55	Oct-56
1964-65	9	-0.6 to -0.8	Weak	Jun-64	Feb-65
1970-71	10	-0.6 to -1.1	Moderate	Jun-70	Apr-71
1971-72	9	-0.7 to -0.9	Weak	May-71	Feb-72
1973-74	12	-0.5 to -2.0	Strong	Jun-73	May-74
1974-75	13	-0.5 to -0.9	Weak	Jun-74	Jun-75
1975-76	11	-0.6 to -1.7	Strong	Jul-75	May-76
1983-84	7	-0.5 to -0.9	Weak	Aug-83	Feb-84
1984-85	13	-0.5 to -1.0	Weak	Sep-84	Sep-85
1988-89	15	-0.6 to -1.8	Strong	Apr-88	Jun-89
1995-96	10	-0.5 to -1.1	Moderate	Jul-95	Apr-96
1998-00	9	-0.9 to -1.8	Strong	Jun-98	01-Apr
2000-01	8	-0.5 to -0.8	Weak	01-Jun	01-Mar
2005-06	7	-0.5 to -0.8	Weak	05-Oct	06-Apr
2007-08	14	-0.6 to -1.6	Strong	07-Jun	08-Jul
2008-09	7	-0.5 to -0.8	Weak	08-Oct	09-Apr
2010-11	14	-1.0 to -1.6	Strong	10-May	11-Jun
2011-12	10	-0.5 to -1.1	Moderate	11-Jul	12-Apr
2016-17	7	-0.5 to -0.7	Weak	16-Jul	17-Jan
2017-18	9	-0.5 to -0.9	Weak	17-Sep	18-May
2020-21	11	-0.6 to -1.3	Moderate	20-Jul	21-May
2021-22	11	-0.7 to -1.1	Moderate	21-Aug	22-Jun
2022-23	7	-0.7 to -1.0	Weak	22-Aug	23-Feb

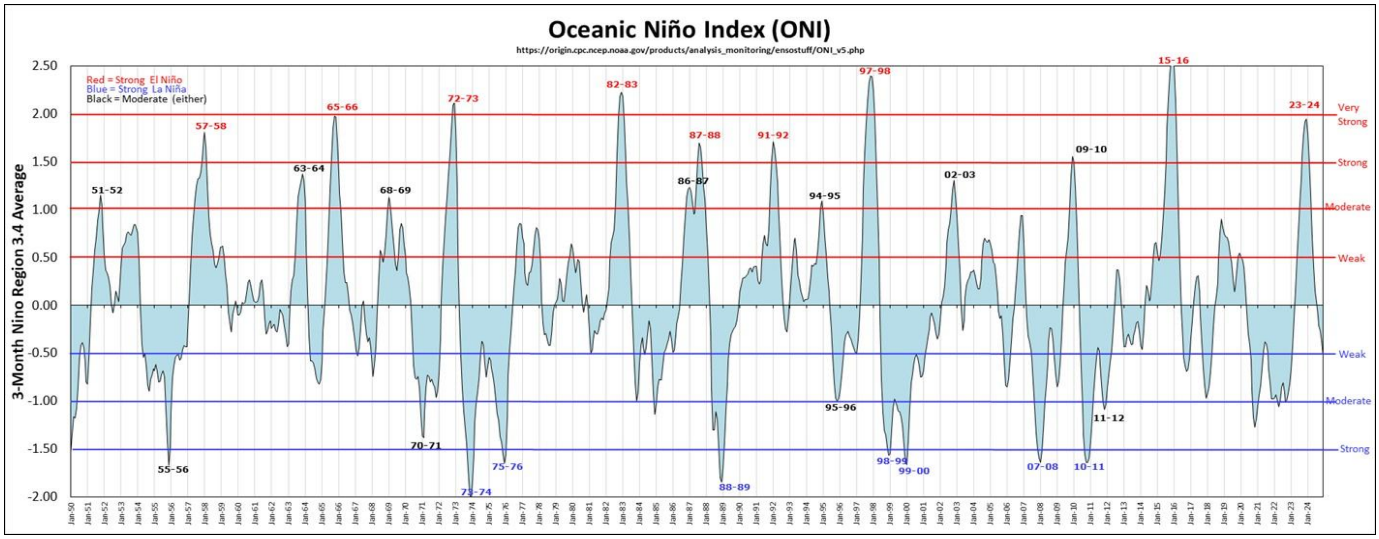

Fig 1: Oceanic Niño Index (ONI) 1950-present (Based on running 3 month mean SST anomaly for the Niño 3.4 region)

Seasonal and annual rainfall during all El Niño years

The most crucial (SWM) season (June-Sept) which is the major crop growing season, negative deviation in rainfall was observed ranging from 1 per cent in Dhamtari to 13 per cent in Balrampur district. However, there was positive deviation in rainfall by 4 per cent in Surguja district. At Agro-Climatic Zones (ACZs) levels, Chhattisgarh plain ACZ and Northen Hills ACZ showed negative deviation in rainfall by 4 per cent, respectively. Bastar plateau ACZ rainfall showed negative deviation by 2 per cent. Overall Chhattisgarh state showed negative deviation in southwest monsoon rainfall by about 3 per cent (Table 4).

Table 4: Per cent change in seasonal and annual rainfall (mm) during all El Niño years (very strong, strong, moderate and weak) compared to normal rainfall (1960- 2023) in Chhattisgarh state.

Districts	Winter season			Summer season			Southwest monsoon			Northeast monsoon			Annual rainfall		
	Average rainfall	El Niño years	% change	Average rainfall	El Niño years	% change	Average rainfall	El Niño years	% change	Average rainfall	El Niño years	% change	Average rainfall	El Niño years	% change
Balod	52	44	-16	82	84	3	898	879	-2	93	80	-14	1124	991	-6
Baloda Bazar	16	18	0	31	49	58	985	941	-4	55	51	-8	1088	1059	-3
Bemetara	15	15	-1	173	165	-5	823	790	-4	30	26	-13	1044	996	-5
Bilaspur	39	39	-1	68	95	40	1039	985	-5	72	74	3	1218	1193	-2
Dhamtari	18	18	2	41	47	14	999	988	-1	91	80	-13	1160	1133	-2
Durg	16	16	-2	24	21	-15	937	887	-5	65	62	-4	1057	999	-5
Gariaband	11	10	-11	26	37	42	1106	1049	-5	51	40	-22	1166	1136	-3
Janjgir Champa	23	20	-14	27	28	4	1076	1018	-5	59	50	-16	1215	1142	-6
Kabirdham	29	30	4	34	39	16	907	869	-4	75	73	-3	1047	1019	-3
Korba	18	8	-55	30	29	-1	1097	1057	-4	59	65	9	1177	1140	-3
Mahasamund	17	22	27	29	47	65	1056	1024	-3	53	45	-14	1155	1139	-1
Mungeli	24	23	-2	30	30	-2	960	928	-3	63	64	1	1077	1044	-3
Raigarh	19	14	-28	56	79	42	1041	1019	-2	65	59	-9	1192	1190	0
Raipur	19	17	-12	45	54	22	1008	962	-5	59	46	-23	1138	1087	-5
Rajnandgaon	17	14	-19	29	30	5	1009	987	-2	68	62	-8	1141	1112	-3
Chhattisgarh Plain Zone	22	21	-8	48	56	19	996	959	-4	64	58	-9	1133	1092	-3
Balrampur	10	2	-80	27	10	-65	1134	989	-13	56	77	39	1227	1078	-12
Jashpur	26	20	-23	46	44	-3	1167	1128	-3	83	67	-19	1322	1260	-5
Koriya	42	24	-42	114	104	-8	1017	991	-3	62	63	2	1219	1183	-3
Surajpur	20	19	-6	39	54	38	1118	1049	-6	56	57	1	1233	1178	-4
Surguja	38	27	-30	50	44	-12	1080	1126	4	82	102	25	1250	1299	4
Northern Hills Zone	27	18	-36	55	51	-10	1103	1057	-4	68	73	9	1250	1199	-4
Bastar	19	16	-20	150	144	-4	1185	1093	-8	111	99	-11	1466	1352	-8
Bijapur	25	20	-18	48	49	2	1217	1152	-5	93	111	18	1384	1335	-4
Dantewada	32	22	-32	117	111	-5	1053	1074	2	73	64	-12	1343	1311	-2
Kanker	16	13	-21	31	26	-16	1053	1059	1	66	64	-3	1166	1162	0
Kondagaon	36	37	3	66	69	5	1012	995	-2	61	27	-55	1174	1129	-4
Narayanpur	19	17	-8	43	34	-19	1263	1287	2	83	71	-15	1411	1419	1
Sukma	8	18	131	60	95	58	1291	1252	-3	67	67	0	1455	1432	-2
Bastar Plateau Zone	22	20	5	74	76	3	1153	1130	-2	79	72	-11	1343	1306	-3
Chhattisgarh state	22	19	-11	52	56	8	1077	1041	-3	70	66	-5	1227	1188	-3

District-wise per cent change in annual rainfall (mm) during all El Niño years irrespective of its intensity were presented (Table 4). It was interpreted from the results that during all El Niño years, negative departure of annual rainfall varied from 1 per cent in Mahasamund to 12 per cent in Balrampur across all the districts of the state. Chhattisgarh Plain ACZ and Northern Hills ACZ showed negative departure by 3 per cent and 4 per cent, respectively. In Bastar Plateau ACZ, a negative deviation of 3 per cent was observed. Overall Chhattisgarh state for this category showed slight negative deviation in annual rainfall by about 3 per cent.

The results are validated based on this study carried out by researchers in past years. Rainfall during El Niño years was likely to be less during southwest monsoon season as compared to non-El Niño years in Himachal Pradesh. Furthermore, rainfall deficiency during SW monsoon increased with strength of the El Niño and subsequent winter season received higher rainfall. Prasad *et al.*, reported similar results. The mean rainfall during El Niño years was less than that during La Niña and normal years. Rishma and Katpatal (2016) [7] have also reported similar results.

Seasonal and annual rainfall during all La Niña years

The most crucial southwest monsoon (SWM) season rainfall (June-Sept) is major crop growing season and important for crop growing periods. Positive deviation in rainfall ranging from 1 per cent in Balodabazar, Bilaspur, Janjgir-Champa, Mungeli, Surguja, Kondagaon to 7 per cent in Kabirdham was observed. However, no change in rainfall in Bemetara, Raipur, Rajnandgaon and Surajpur district were observed. Chhattisgarh Plains ACZ showed no change in southwest monsoon rainfall, Northern Hills ACZ showed positive deviation in rainfall by 1 per cent and Bastar plateau ACZ showed negative deviation in rainfall by 1 per cent (Table 5).

Percent change in district-wise annual rainfall during all La Niña years irrespective of its intensity were presented (Table 5). It can be seen from the results that during all La Niña years, positive deviation in annual rainfall varied from 1 per cent in Bemetara/ Bilaspur/ Dhamtari/ Mungeli to 6 per cent in Kabirdham district was observed. Some districts like Balod, Durg, Gariaband, Raigarh, Kanker, Narayanpur and Sukma showed negative deviation in annual rainfall. Rainfall at Agro-Climatic Zones (ACZs) level was analyzed and there is no change in annual rainfall in Bastar Plateau ACZ. Positive deviation in annual rainfall by 1 per cent and 2 per cent was observed in Chhattisgarh Plains ACZ and Northern Hills ACZ, respectively. Overall Chhattisgarh state for this category showed slightly positive deviation in annual rainfall by about 1 per cent.

Table 5: Per cent change in seasonal and annual rainfall (mm) during all La Niña years (strong, moderate and weak) compared to normal rainfall (1960-2023) in Chhattisgarh state.

Districts	Winter season			Summer season			Southwest monsoon			Northeast monsoon			Annual rainfall		
	Average rainfall	La Niña years	% change	Average rainfall	La Niña years	% change	Average rainfall	La Niña years	% change	Average rainfall	La Niña years	% change	Average rainfall	La Niña years	% change
Balod	52	62	20	82	73	-10	898	871	-3	93	97	5	1124	1100	-2
Baloda Bazar	16	20	22	31	19	-38	985	994	1	55	57	3	1088	1090	0
Bemetara	15	18	18	173	180	4	823	827	0	30	23	-21	1044	954	1
Bilaspur	39	42	6	68	61	-11	1039	1053	1	72	71	-1	1218	1227	1
Dhamtari	18	23	28	41	39	-7	999	964	-3	91	115	26	1160	1171	1
Durg	16	24	47	24	28	14	937	932	-1	65	68	5	1057	1162	-5
Gariaband	11	15	34	26	28	5	1106	1034	-7	51	59	15	1166	1135	-3
Janjgir Champa	23	30	29	27	23	-15	1076	1092	1	59	70	18	1215	1269	5
Kabiedham	29	35	22	34	26	-24	907	967	7	75	82	9	1047	1110	6
Korba	18	35	89	30	33	13	1097	1163	6	59	59	1	1177	1239	5
Mahasamund	17	20	17	29	23	-20	1056	1036	-2	53	63	20	1155	1143	-1
Mungeli	24	25	5	30	22	-27	960	972	1	63	65	3	1077	1084	1
Raigarh	19	23	20	56	50	-11	1041	1009	-3	65	62	-5	1192	1144	-4
Raipur	19	24	29	45	37	-16	1008	1008	0	59	71	21	1138	1157	2
Rajnandgaon	17	25	45	29	30	5	1009	1010	0	68	81	19	1141	1170	3
Chhattisgarh Plain Zone	22	28	29	48	45	-9	996	996	0	64	70	8	1133	1144	1
Balrampur	10	11	6	27	40	47	1134	1155	2	56	37	-33	1227	1243	1
Jashpur	26	31	21	46	55	20	1167	1228	5	83	98	17	1322	1412	7
Koriya	42	54	28	114	158	39	1017	1008	-1	62	60	-4	1219	1237	0
Surajpur	20	20	1	39	40	3	1118	1119	0	56	55	-3	1233	1233	0
Surguja	38	39	4	50	63	27	1080	1086	1	82	67	-18	1250	1256	1
Northern Hills Zone	27	31	12	55	71	27	1103	1119	1	68	63	-8	1250	1276	2
Bastar	19	24	25	150	148	-1	1185	1211	2	111	111	1	1466	1495	2
Bijapur	25	32	27	48	44	-8	1217	1250	3	93	107	15	1384	1433	4
Dantewada	32	43	32	117	124	6	1053	1023	-3	73	81	11	1343	1349	1
Kanker	16	21	30	31	39	26	1053	1015	-4	66	51	-24	1166	1125	-4
Kondagaon	36	42	18	66	76	16	1012	1019	1	61	73	21	1174	1210	3
Narayanpur	19	26	39	43	52	23	1263	1178	-7	83	101	21	1411	1357	-4
Sukma	8	3	-59	60	41	-32	1291	1267	-2	67	131	97	1455	1442	-1
Bastar Plateau Zone	22	27	16	74	75	4	1153	1137	-1	79	94	20	1343	1345	0
Chhattisgarh state	23	28	22	52	55	4	1077	1076	0	70	77	9	1227	1243	1

Conclusion

Results revealed that generally El Niño and La Niña event occur every 3-4 years. El Niño event is more frequent than La Niña event. Weak El Niño and La Niña eventsare more frequent than other El Niño and La Niña events, respectively. Result on occurrence & frequency of El-Niño and La-Niña in Chhattisgarh state were analyzed since 1951.It was found that annual rainfall for state as a whole decreased by 3 per cent during El Niño years (irrespective of very strong, strong, moderate and weak El Niño years) as compared to average annual rainfall. The effect was more pronounced on rainfall during strong El Niño years than very strong El Niño years. At district level, negative deviation in rainfall during southwest monsoon was highest in Balrampur (13%) and lowest in Dhamtari district (1%). During La Niña years (irrespective of strong, moderate and weak La Niña years) annual rainfall for state as a whole increased by 1 per cent as compared to average annual rainfall. The positive effect was more pronounced during strong La Niña years than moderate and weak La Niña years. At district level, positive deviation in rainfall during southwest monsoon was highest in Kabirdham (7%) and lowest in Baloda-Bazar, Bilaspur, Janjgir-Champa, Mungeli, Surguja and Kondagaon districts (1%).

References

1. Anonymous. El Niño/southern oscillation. Geneva: World Meteorological Organization (WMO); 2014.
2. Null J. El Niño and La Niña Intensities [Internet]. 2023 [cited 2025 Sep 24]. Available from: http://ggweather.com/enso/oni.htm
3. Nicolls N. Teleconnection and Health–Teleconnection linking worldwide climate anomalies. Cambridge: Cambridge University Press; 1991. p. 493-510.
4. Patel HR, Lunagaria MM, Pandey V, Sharma PK, Rao BB, Rao VUM. El Niño episodes and agricultural productivity in Gujarat. Technical Report No. 01/2014-15. Anand, Gujarat: Department of Agricultural Meteorology, AAU; 2014.
5. Rao VUM, Subba Rao AVM, Bapuji Rao B, Ramana Rao BV, Sravani C, Venkateswarlu B. El Niño effect on climatic variability and crop production: a case study for Andhra Pradesh. Research Bulletin No. 2/2011. Hyderabad: CRIDA; 2011. p. 36.
6. Radi FA. Foundations of climatic and vegetative geography. Beirut, Lebanon: Arab Renaissance House; 2004.
7. Rishma C, Katpatal YB. Variability in rainfall and vegetation density as a response to ENSO events: a case study in Venna river basin of Central India. J Agrometeorol. 2016;18(2):300-305.