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Effect of El-Nino on rainfall and temperature of Eastern Plain Zone of Uttar Pradesh

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Abstract
District wise monthly rainfall data of Eastern Plain Zone of Uttar Pradesh recorded during the years 1981 to 2017 were used in the present study. The rainfall totals for the summer (March to May), South-West monsoon (June to September), rabi (October to December) and winter (January to February) seasons were computed year wise for various districts of Eastern Plain Zone of U.P. The inter-seasonal and intra-seasonal variability in weather is believed in recent years to outsmart the abilities of climatologist and statisticians in defining the limits within which these variabilities can be observed. El-Nino is a pervasive climatic phenomenon that was found to be associated with regional climate variations throughout the world. Analysis of long term data suggests an inverse relationship between El-Nino and South-West monsoon rainfall. However, there is no one to one relationship as El-Nino years have not always produced severe drought. The analysis was performed to assess the association between El-Nino episodes on rainfall and temperature in the Eastern Plain Zone of U.P. The average South-West monsoon rainfall, summer rainfall, Winter rainfall, and total annual rainfall received during the years with El-Nino were found to be less compared to normal years, In general, it was observed that the South-West monsoon rainfall and the annual rainfall was found less during the El-Nino years. The mean annual temperature was found not to vary much during El-Nino years.

Keywords: rainfall, temperature, drought, monsoon, weather, climate variation

Introduction
Rainfall is the direct source for both rainfed and irrigated agriculture. In general, it drives the agricultural productivity of India. The quantum and the distribution of rainfall determine agricultural productivity. In Eastern Plain Zone of Uttar Pradesh, It determines not only the crop selections during the Kharif season but also the crop sequences in double-cropping systems during rabi seasons. Thus the monsoon rainfall and its distribution are very crucial for crop success in Eastern Plain Zone of Uttar Pradesh. It is known that whatever be the quantum of rainfall over India, some regions of India receive normal, some parts receive below normal, while some others receive above-normal rainfall. This type of spatial distribution of rainfall is important from the angle of agricultural planning. El-Nino is one of the most important factors that govern monsoonal rainfall over India. Assessment of the role of El-Nino on regional rainfall and agriculture has been attempted for the states of Andhra Pradesh (Rao *et al*., 2011) [5], Gujarat (Patel *et al*., 2014) [4] and Karnataka (Venkatesh *et al*., 2015) [7]. Among several factors that govern agricultural production, the weather appears to be the most critical factor as the farmers have no control over it and its inter and intraseasonal variability are difficult to predict with greater reliability and confidence. So, the farmers generally believe that the weather in the coming year will be different from what they were aware of in the past. In tropical countries like India, a region may experience a dry spell because no storms happen to pass that way for a time. Prediction of such stochastic events is not possible. Climatologists, now see, however, that many climatic variations are part of large scale, slowly evolving patterns. Many critical agricultural decisions from farm to policy level must be made several months before those weather conditions are experienced. Kothawale *et al*. (2010) observed that the during period 1901 to 2007 Indian annual mean, maximum and minimum temperature showed significant warming trends of 0.51 ºC, 0.72 ºC, and 0.27 ºC 100 year^{-1}, respectively, However, severe warming in the recent decade 1998-2007 has accelerated the warming during 1971–2007. The mean, maximum, minimum temperatures have increased by about 0.2 ºC per decade for the period 1971-2007. Asseng *et al.* (2010) [1] observed variations in average growing-season temperatures of ±2 °C in the main wheat growing regions of Australia can

cause reductions in grain production of up to 50%. Sita Kumari *et al*. (2017) analyzed that the temperature increases can result in heat stress a severe threat to crop production in most countries. Legumes are well-known for their impact on agricultural sustainability as well as their nutritional and health benefits.

Materials and Methods

Rainfall data

District-wise monthly rainfall data under of Eastern Plain Zone of U.P. recorded during the years 1981 to 2017, were used under the present study. The total rainfall for the summer (March to May), southwest monsoon (June to September), rabi (October - December) and winter (January - February) seasons were computed year-wise for various districts of the Eastern Plain Zone of U.P.

Temperature data

The monthly temperature data for all the years 1981-2017 was recorded at 9 stations spread in Eastern Plain Zone of U.P. were analyzed to find the mean seasonal maximum and minimum temperature during different seasons were considered for the present study.

According to Jan Null (2011), the Oceanic Nino Index (ONI) has become the defect standard that NOAA uses for identifying El Nino (Warm) and La Nina (Cool) events in the tropical pacific for the Nino 3.4 region (i.e., 5^0 N to 5^0 6, 120^0 -170^0 W). Events are defined as five consecutive months at or above the +0.5 ^{0}C anomaly for warm (El Nino) events. The threshold is further broken down into weak with a 0.5 to 0.9 sea surface temperature anomaly, Moderate (1.0 to 1.4), and Strong (1.5) events. For weak, moderate, or strong, it must have equalled or exceeded the threshold for at least 3 months. Accordingly, the El Nino years were classified from 1951 to 2017 as follows:

Table 1: Shows intensity and years

Intensity	Years
Weak	1951, 1963, 1968, 1969, 1976, 1977, 2004, 2006
Moderate	1986, 1987, 1994, 2002
Strong	1957, 1965, 1972, 1982, 1991, 1997, 2009, 2014, 2015

During the period considered for the present study from 1981 to 2017, there were 10 moderate and strong and two weak El Nino events out of 37 years.

Result and Discussion

The percentage change in seasonal rainfall during the El-Nino years compared to normal rainfall was computed for the seasons in different districts. The average rainfall during the South-West (S-W) monsoon season during the El-Nino years was less than the normal rainfall in all the districts of Eastern Plain Zone of U.P. The departure was maximum in Jaunpur district by 9.2 per cent followed by Barabanki district (9.0%). The lowest departure (1%) was recorded in the Mau district of Eastern Plain Zone of the U.P.

The average summer season rainfall during El-Nino years from March to May was less than the normal rainfall in Eastern Plain Zone of U.P. The maximum departure (10.1 per cent) was recorded in Ghazipur district followed by 8.4% in Barabanki district. The minimum departure (1%) over normal rainfall was recorded in Ballia district.

The average rainfall during winter season during El-Nino years from January to February was less than the normal rainfall in all the districts of Eastern Plain Zone of U.P. as evident in Table 1. The maximum departure (14.9%) was recorded in Ghazipur district followed by Jaunpur district. The average rainfall during the post-monsoon (October to December) during El-Nino years was almost less than the normal rainfall in Eastern Plain Zone of U.P. during the El-Nino years as compared to normal rainfall.

Annual rainfall

The percentage change in district wise average annual rainfall during the El-Nino years as compared to normal rainfall of different selected districts of Eastern Plain Zone of U.P. has been given in Table 2. The average annual rainfall during El-Nino years is less than normal years. Maximum departure (5.7%) was recorded in Ballia district followed by Jaunpur district (5.1%) as evident in Table 4.2. The lowest departure of 0.4% was found in Varanasi district followed by Barabanki district (1.1%) of Eastern Plain Zone of U.P.

The average annual rainfall and South-West monsoon season rainfall were less than normal rainfall during the years with El-Nino. Hence, El-Nino unambiguously serves as a signal of deficit rainfall for the Eastern Plain Zone of U.P. during the southwest monsoon season and if it does not happen, leads to deficit annual rainfall.

Temperature

The mean annual temperature during El-Nino years of the selected station of Eastern Plain Zone of U.P. as compared to normal years temperature has been presented in Table 3. There is a slight increase in annual temperature by 0.1 to 0.5 ^{o}C during El-Nino years as compared to normal years temperature. Hence, the temperature seems to be affected by the El-Nino factor in the zone.

Table 1: Per cent change in average seasonal rainfall (mm) during El-Nino years as compared to normal years rainfall (mm) in Eastern Plain Zone of U.P

Name of Districts	Winter (JAN-FEB)			Summer (MAR-MAY)			SW Monsoon (JUN-SEPT)			Post Monsoon (OCT-DEC)		
	El Nino (Y)	N (Y)	PC*	El Nino (Y)	N (Y)	PC*	El Nino (Y)	N (Y)	PC*	El Nino (Y)	N (Y)	PC*
Varanasi	82	87.7	-6.5	67	72.7	-7.8	876	926.7	-5.5	58	67.4	-13.9
Jaunpur	48	53.9	-10.9	78	84.4	-7.6	805	886.2	-9.2	70	72.2	-3.0
Ghazipur	40	47	-14.9	67	74.5	-10.1	910	929.8	-2.1	44	66.5	-33.8
Ballia	44	46.3	-5.0	70	70.7	-1.0	913	892.2	2.3	58	67.4	-13.9
Azamgarh	47	51.8	-9.3	76	78.4	-3.1	873	899.7	-3.0	75	73.6	1.9
Mau	44	48	-8.3	74	80	-7.5	890	900	-1.0	60	65	-7.7
Faizabad	72	79.8	-9.8	109	103.5	5.3	860	891.3	-3.5	90	86.8	3.7
Sultanpur	63	66.7	-5.5	93	100.6	-7.6	825	886.9	-7.0	75	72.5	3.4
Barabanki	58	64	-9.4	81	88.4	-8.4	800	878.7	-9.0	68	74.8	-9.1

*PC indicates the per cent change

Table 2: Per cent change in district-wise average annual rainfall (mm) during El-Nino years as compared to normal years rainfall in Eastern Plain Zone of U.P.

Name of Districts	Rainfall (mm)		
	El-Nino years	Normal years	Percentage change
Varanasi	1083	1079	0.4
Jaunpur	937	987	-5.1
Ghazipur	1005	1034	-2.8
Ballia	927	983	-5.7
Azamgarh	1003	1031	-2.7
Mau	1044	1070	-2.4
Faizabad	985	1001	-1.6
Sultanpur	990	1005	-1.5
Barabanki	1044	1056	-1.1

Table 3: Mean annual temperature (°C) during El-Nino years as compared to normal years temperature at some selected location in Eastern Plain Zone of U.P.

Stations	El-Nino Years	Normal Years	Difference
Varanasi	26.9	26.6	0.3
Jaunpur	30.5	30	0.5
Ghazipur	25.2	25	0.2
Ballia	27.8	27.5	0.3
Azamgarh	26.5	26.3	0.2
Mau	26.4	26.2	0.2
Faizabad	25.6	25.5	0.1
Sultanpur	26.5	26.3	0.2
Barabanki	26.8	26.5	0.3

Conclusion

District-wise monthly rainfall data for various districts of Eastern Plain Zone of Uttar Pradesh recorded during the years 1981 to 2017, were used in the present study. The rainfall totals for the summer (March to May), South-West monsoon (June to September), rabi (October-December) and winter (January - February) seasons were computed year wise for various districts of Eastern Plain Zone of U.P. The inter-seasonal and intra-seasonal variability in weather is believed in recent years to outsmart the abilities of climatologist and statisticians in defining the limits within which these variabilities can be observed. El-Nino is fundamentally warming of the surface water of the tropical Eastern Pacific Ocean from the South American coast to the International Date Line that persists for three or more seasons. El-Nino is a pervasive climatic phenomenon that was found to be associated with regional climate variations throughout the world. There is no one to one relationship as El-Nino years have not always produced severe drought. The average South-West monsoon rainfall, summer rainfall, winter rainfall, and total annual rainfall received during the years with El-Nino were found to be less compared to normal years, In general, it was observed that either the South-West monsoon rainfall or the annual rainfall will be less during the El-Nino years. The mean annual temperature was found not to vary much during El-Nino years.

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