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Short Comminucation

El Niño and seasonal rainfall dynamics vis-à-vis food grain productivity in Himachal Pradesh

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Agriculture is the main occupation and source of livelihood for more than 71 per cent of total population in Himachal Pradesh. Nearly10.4 per cent of the total Gross Domestic Product comes from agriculture and its allied sectors (Anonymous, 2016). About 81 per cent of the total cultivated area in the state is rainfed. The mean annual rainfall of the state is 1267mm. The southwest monsoon is the predominant rainy season in the state contributing to about 69 per cent of the total annual rainfall followed by summer season (13 per cent) and winter season rains (11 per cent) (Prasad *et al*., 2016).

The Indian summer monsoon rainfall has been closely related with the El Niño–southern oscillation (ENSO) events (Webster *et al.,* 1998; Singh *et al.,* 2005). About 90 per cent of all evolving El Niño years during 1880 to 2005 have led to below normal rainfall and 65 per cent of evolving El Niño years has brought droughts. In the most prominent droughts in India, six of them since 1871 have been El Niño droughts, including the recent ones in 2002 and 2009.The mean rainfall has also been less during El Niño years than La Niña and normal years in Maharashtra as stated by Rishma and Katpatal (2016). Manikandan *et al*. (2016) also reported negative departure in annual rainfall ranging from 1 to 10 per cent in different districts of Chhattisgarh. Patel *et al*.(2014) observed that variability in annual rainfall was high and widespread in Gujarat indicating the influence of El Niño on the rainfall.However, there is no one to one relationship as El Niño years have not always produced severe droughts. Moreover studies on the effect of El Niño either on crop production or productivity at regional level are meager. In the light of above, an attempt has been made to study the changes in annual and seasonal rainfall during El Niño years as well as to assess the changes in productivity of major cereal grains in different districts of Himachal Pradesh.

The district-wise monthly rainfall data for ten districts of Himachal Pradesh *viz*., Bilaspur, Chamba, Hamirpur, Kangra, Kullu, Sirmaur, Solan, Shimla, Una and Mandi documented for the years 1971-2014, as available in the database at CSK HPKV,Palampur was used for the present study. Rainfall for southwest monsoon (June-September) and winter (October-May) seasons was aggregated for each year. The de-facto standard of Oceanic Niño Index (ONI) of NOAA used for identifying El Niño (Warm) and La Niña (Cool) events in the tropical Pacific for the Nino 3.4 region (i.e., 5°N to 5°6, 120°- 170°W) following Jan Null (2016). The El Niño years were classified into weak (0.5 to 0.9°C), moderate (1.0 to 1.4°C) and strong (above 1.5°C), based on the threshold values that persisted for at least three months and grouped the rainfall years accordingly. The years were then categorized as non El Niño years (years with normal rainfall), weak El Niño years, moderate El Niño years and strong El Niño years (Table 1). The mean rainfall for different El Niño years and years with normal rainfall for each district were deduced by averaging the corresponding data. The area and productivity of rice, maize, wheat and barley crops in different districts of Himachal Pradesh for the years 1981-82 to 2013-14 were obtained from Directorate of Agriculture, Shimla.

Table 1: Classification of El Niño years based on SST anomaly (1971-2014)

Intensity	Years
Weak (6 No.)	1976-77, 1977-78, 1979-80, 1994-95, 2004-05, 2006-07
Moderate (5 No.)	1986-87, 1987-88, 1991-92, 2002-03, 2009-10
Strong (4 No.)	1972-73, 1982-83, 1997-98, 2015-16
Non El Niño (31 No.)	Remaining years (years with normal rainfall)

The percentage change in average annual rainfall during the El Niño years compared to non El Niño years for selected districts of the state showed that the rainfall during El Niño years was less as compared to non El Niño years in majority of the districts (Table 2).The decrease was 26 per cent in Solan, 19 per cent in Mandi and 17 per cent in Kangra

Table 2: Per cent change (PC) in district wise rainfall (mm) during El Nino years as compared to non El Niño years

District	Annual rainfall (mm)			Southwest monsoon			Winter		
	El Nino years	Non El Nino years	PC	El Nino years	Non El Nino years	PC	El Nino years	Non El Nino years	PC
Bilaspur	1091	1201	-9	736	906	-19	356	295	21
Chamba	1176	1181	0	587	602	-2	589	579	2
Hamirpur	1442	1335	8	1141	1027	11	301	309	-2
Kangra	961	1164	-17	722	945	-24	239	220	9
Kullu	954	1061	-10	631	750	-16	323	311	4
Sirmaur	921	1045	-12	747	875	-15	174	170	2
Solan	892	1203	-26	674	976	-31	218	228	-4
Shimla	917	999	-8	687	774	-11	230	225	2
Una	1040	1127	-8	786	914	-14	254	213	20
Mandi	1289	1590	-19	929	1195	-22	360	395	-9

Table 3: Per cent change in productivity of different crops during El Niño years compared to non El Nino years in Himachal Pradesh

District	Maize			Rice			Wheat			Barley		
	El Nino years	Non El Nino years	PC	El Nino years	Non El Nino years	PC	El Nino years	Non El Nino years	PC	El Nino years	Non El Nino years	PC
Bilaspur	1558	1824	-15	1153	1379	-16	1444	1309	10	1258	1238	2
Chamba	2269	2445	-7	1377	1393	-1	1290	1399	-8	1087	1177	-8
Hamirpur	1524	1752	-13	1076	1302	-17	1280	1082	18	1260	1239	2
Kangra	1462	1698	-14	1231	1389	-11	1426	1399	2	1184	1211	-2
Kullu	1983	2601	-24	1344	1355	-1	1691	1691	0	1529	1407	9
Mandi	2273	2488	-9	1219	1321	-8	1418	1311	8	1430	1321	8
Shimla	1915	2203	-13	1112	1194	-7	1186	1241	-4	1268	1218	4
Sirmaur	2275	2688	-15	1410	1669	-16	1499	1470	2	1053	1160	-9
Solan	1792	2225	-19	1630	1727	-6	1415	1398	1	1101	913	21
Una	1689	1828	-8	1631	1742	-6	1466	1514	-3	635	794	-20
HP State	1843	2117	-13	1266	1404	-10	1414	1371	3	1270	1238	3

district. The yearly annual rainfall was less than normal in 8 out of 14 El Niño years from 1971 to 2014. The annual rainfall is hence expected to be below average with 60 per cent probability during El Niño years.

The southwest monsoon also received less rainfall (-2 to -24%) during El Niño years than non El Niño years in all the districts except Hamirpur which received higher (+11%) rainfall in El Niño years.However, the winter season rainfall was observed to be higher during El Niño years in 7 out of 10 selected districts of the state. The increase in winter rainfall was 21 per cent in Bilaspur, 20 per cent in Una and 9 per cent in Kangra district.Other districts also observed increase in rainfall ranging from 2 to 4 per cent (Table 2).

Maize and rice are two important *kharif* crops in Himachal Pradesh, while wheat and barely are two important *rabi* crops. The impact of El Niño on productivity of these crops are presented in Table 3. Maize is grown in all the districts of the state and covers an area of 2.93lakh hectares and ranks first in production among cereal crops grown in Himachal Pradesh. The productivity of maize in the state declined by 13 per cent during El Niño years (Table 3). All the districts of the state showed reduction in the productivity and it was highest in Kullu (24 per cent) followed by Solan (19 per cent) district. The productivity of rice decreased by

10 per cent in the state during El Niño years. Kangra and Mandi districts having largest acreage, showed a reduction in productivity of about 11 and 8 per cent, respectively. The maximum reduction in rice productivity was 17 per cent in Hamirpur. Wheat being an important *rabi* crop of the state, covers about 3.5 lakh hectare area. The productivity of wheat in the state was positively influenced during El Niño year in most of the districts with overall increase of 3 per cent, however in Chamba, Shimla and Una districts the wheat yield decreased. This was mainly due to increase in rainfall during winter season in El Niño years.Prasanna (2014) revealed that the *rabi* crops are not only directly affected by variations in the post-monsoon precipitation (October–December) alone but the summer season precipitation also influences the *rabi* crops through water and soil moisture availability. The productivity of barley in the state during El Niño years increased by 3 per cent. The positive influence of El Niño on barley productivity was observed in six out of 10 districts with the highest increase (21%) in productivity in Solan district.

The anomalies in seasonal rainfall for the years with weak, moderate and strong El Niño for different districts of the state indicated that during south west monsoon, rainfall deficiency mostly increased with strength of the El Niño while subsequent winter season received higher rainfall. Hence, El Niño had a compensatory effect on winter rains. The weak or strong El Niño attracted higher winter rains while the moderate El Niño caused reduction in south west monsoon rainfall (Prasad *et al.*, 2014).The maize yield of most of the districts was positively affected by the weak El Niño while moderate and strong El Niño years negatively affected it. In rice, wheat and barley the weak and strong El Niño positively affected the productivity in most of these crops growing districts while the moderate El Niño had negative impact.This indicates that moderate and strong El Niño years influence the productivity of the crop perhaps depending upon the location of the district. Similar observation has also been made by Patel *et al*. (2014) for Gujarat state.

Thus, it can be concluded that the southwest monsoon rainfall or annual rainfall is likely to decrease with a possibility of increased winter rain in most of the districts of the state during El Niño years.The study indicates that though, there is no evidence of one to one correspondence of higher rainfall following El Niño but Himachal Pradesh in general received higher winter rainfall following weak El Niño and thereby partially compensated the losses caused in food grains.

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