

**ICAR - Central Research Institute for Dryland Agriculture
Hyderabad, Telangana**

**Reply to the admitted question for the Lok Sabha - Q.No. S3903, S3900 and S3922 due for
reply on 15.07.2019 regarding "Changes in rain cycle"**

a) Whether any study has been conducted on the changes in rain cycle during the last decade due to climate change to ascertain in the extent of reduction in rainfall and its effects;

Ans:

Trends in rainfall over India (1951-2010)

Annual average rainfall trends in India

State averaged annual rainfall trends have increased over Andhra Pradesh, Bihar, Gujarat, Haryana, Jammu and Kashmir, Jharkhand, Lakshadweep, Manipur, Meghalaya, Mizoram, Orissa, Rajasthan, Tamil Nadu, Tripura and West Bengal during 1951-2010 (in Figure 1). However, annual rainfall has decreased over Andaman and Nicobar, Arunachal Pradesh, Assam, Chhattisgarh, Delhi, Goa, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Nagaland, Punjab, Sikkim and Uttar Pradesh. The highest increase and decrease in annual rainfall were observed over Meghalaya (+14.68 mm/year) and Andaman and Nicobar (-7.77 mm/year) respectively (Table 1). However, annual rainfall trends have been significantly increasing over West Bengal (+3.63 mm/year) and significantly decreasing over Andaman and Nicobar (-7.77 mm/year) and Uttar Pradesh (-4.42 mm/year)

Monsoon season rainfall trends

State averaged monsoon season rainfall has increased over Bihar, Gujarat, Jharkhand, Karnataka, Lakshadweep, Meghalaya, Mizoram and West Bengal during 1951-2010 (Figure 2). The highest increase (non-significant) in rainfall was found over Meghalaya and Mizoram (Table 1). Decreasing trend in monsoon rainfall have been observed over Andaman and Nicobar, Andhra Pradesh, Arunachal Pradesh, Assam, Chhattisgarh, Delhi, Goa, Haryana, Himachal Pradesh, Jammu and Kashmir, Kerala, Madhya Pradesh, Maharashtra, Manipur, Nagaland, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu, Tripura, Uttar Pradesh and Uttarakhand. Andaman and Nicobar and Himachal Pradesh have shown highest decline trends (non-significant) in monsoon season rainfall, while significantly decrease has been observed over Tamil Nadu (-1.35 mm/year) and Uttar Pradesh (-3.52 mm/year).

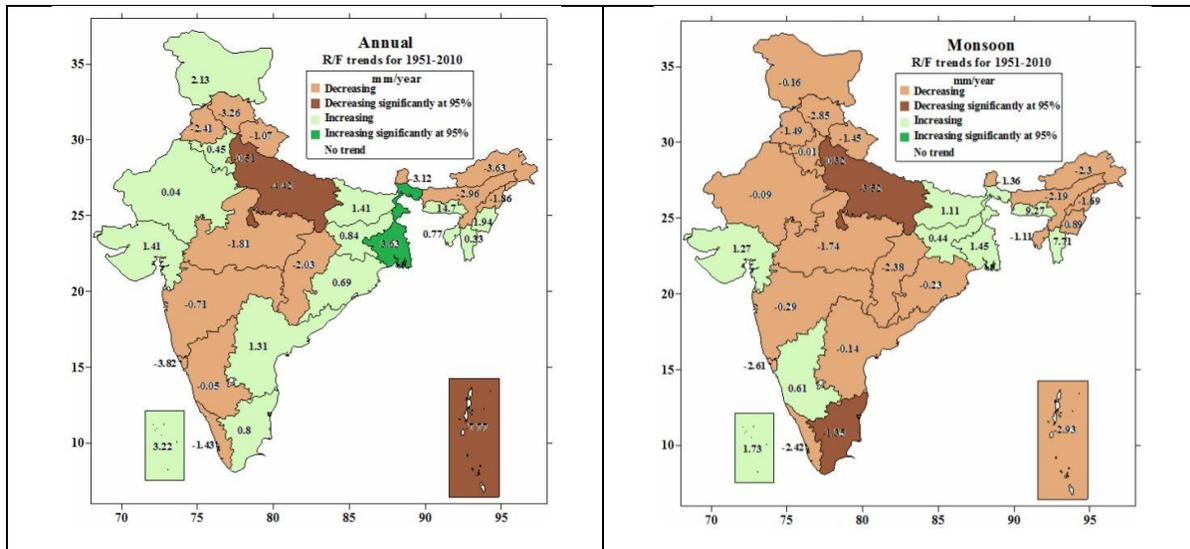


Fig.1-2: Trends in annual and monsoon rainfall in India

Reference - <http://www.imd.gov.in/section/climate/StateLevelClimateChangeMonoFinal.pdf>

b) The details of the areas affected due to changes in rain cycle in the last decade and the steps taken by Ministry to resolve this; and

Ans. Analysis of sub-division wise rainfall of current decade (2008-2017) and the previous (1998-2007) decade in comparison with the 30 year normal (1961-1990) reveals that

- Punjab subdivision experienced rainfall deficit during winter (-24%), southwest monsoon (-23%) post monsoon (-50%) and annual rainfall (-24%) in the decade 2008-2017. In the previous decade (1998-2007) also Punjab experienced deficit rainfall condition during summer (-27%), southwest monsoon (-29%), post monsoon (-47%) and annual rainfall (-27%).
- All the remaining subdivisions experienced normal or above in southwest monsoon and annual rainfall during both decades.
- In the current decade (2008-2017) it is observed that deficit rainfall during winter was experienced in the meteorological subdivisions viz., Assam & Meghalaya (-39%), Bihar(-31%), Haryana(-24%), Jharkhand (-36%), Nagaland-Manipur-Mizoram-Tripura(-36%), Punjab (-24%), Konkan & Goa (-76%), Sub-Himalayan West Bengal & Sikkim (-27%), Tamilnadu (-30%) and Vidarbha (-44%), while it was normal during the previous decade (1998-2007) over these subdivisions.
- The pre-monsoon rainfall during summer season is found deficit over the subdivisions of Coastal Karnataka (-27%), Gujarat (-60%), Konkan & Goa (-46%) and Madhya Maharashtra (-20%) during the current decade (2008-2017), while it was normal during the previous decade (1998-2007).

LEGEND										
Large Excess: +60 and above										
Excess: +20 to +59										
Normal: +19 to -19										
Deficient: -20 to -59										
Large Deficient: -60 to -99										
No Rain: -100										
Subdivision	1998-2007					2008-2017				
	Winter (JF)	Summer (MAM)	SW Monsoon (JJAS)	P Monsoon (OND)	Annual	Winter (JF)	Summer (MAM)	SW Monsoon (JJAS)	P Monsoon (OND)	Annual
Assam & Meghalaya	14	8	-5	10	0	-39	4	-6	-30	-6
Bihar	-16	24	0	-8	1	-31	21	-11	-31	-11
Chhattisgarh	29	-6	-1	1	0	-7	-10	1	10	1
Coastal AP	31	-3	5	-5	1	12	9	6	-11	0
Coastal Karnataka	9	79	-4	11	1	294	-27	-5	22	-4
East MP	-27	29	-5	-23	-6	-19	10	-4	-8	-5
East Rajasthan	-2	6	-10	3	-9	18	19	9	-19	8
East UP	-10	28	-9	-35	-10	6	13	-16	-37	-16
Gangetic WB	-8	16	5	48	10	-3	9	-5	-13	-4
Gujarat	38	-18	11	-20	10	-9	-60	11	-24	9
Haryana	33	38	-16	0	-9	-24	22	-16	-54	-15
Jharkhand	15	14	3	29	6	-36	-8	-6	1	-7
Kerala	2	19	-10	15	-2	-15	-4	-8	6	-5
Konkan & Goa	35	165	6	9	9	-76	-46	11	44	11
Madhya Maharashtra	9	-3	9	-14	5	14	-20	4	8	4
Marathwada	-43	-6	2	8	2	-47	-17	-7	-33	-11
NI Karnataka	-33	-5	-9	-10	-9	11	-2	-9	-12	-9
NMMT	-3	7	-2	-5	0	-36	-8	-5	-21	-8
Odisha	-33	5	2	20	3	-33	-6	8	6	5
Punjab	8	-27	-29	-47	-27	-24	-18	-23	-50	-24
Rayalaseema	-34	50	6	5	10	34	10	3	2	4
Saurashtra & Katch	-58	146	15	6	16	-33	6	38	-19	33
SHWB&Sikkim	14	14	1	19	4	-27	11	-2	-22	-2
SI Karnataka	35	6	-2	9	2	17	22	7	-7	6
Tamilnadu	-17	19	-14	3	-2	-30	29	-6	8	4
Telangana	55	-6	-10	-17	-10	12	12	-9	-26	-10
Vidarbha	5	32	3	-18	3	-44	-5	-2	-30	-5
West MP	1	81	-8	-43	-9	37	-2	3	-24	2
West Rajasthan	28	5	-13	24	-9	-14	5	24	-16	20
West UP	14	25	-7	-20	-5	6	-1	-16	-48	-16

Fig. 3: Decadal variation in rainfall across Meteorological sub-divisions of India during the current decade (2008-2017) and previous (1998-2007) decade. (source: AICRPAM Unpublished)

Impact of rainfall deficit of crop productivity

Due to the deficit in rainfall during 2002 (-19%), 2004 (-13%), 2009 (-23%), 2014 (-12%), 2015 (-14%) and 2018 (-9%), the crop productivity during these years got reduced in comparison with the previous years (Fig. 3).

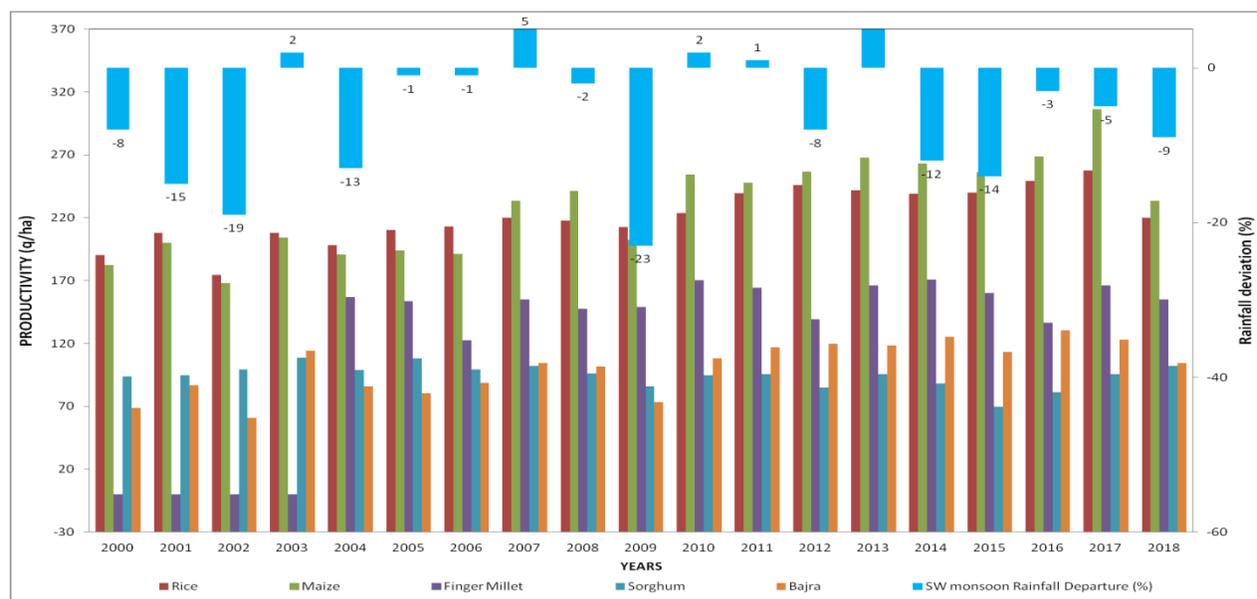


Fig. 3: Productivity (Kg/ha) of Food Grain Crops in India and Rainfall Departure during 2000-2018 (source: AICRPAM Unpublished)

c) The details of steps taken to provide accurate forecast related to changes in rain cycle to farmers and to common people

Farmers are being sensitized through farmers' awareness programs regarding the climate change, change in rainfall pattern and its likely impacts on different crops of India by **IMD-Gramin Krishi Mausam Seva**, **ICAR-CRIDA-AICRPAM**- Micro-level Agroadvisory Services.

ANNEXURE

Table 1: State-level annual and seasonal rainfall trends

State level annual and seasonal rainfall trends based upon 1451 rainfall stations for 1951-2010. Increasing (+) and decreasing (-) trends significant at 95% level of significance are shown in bold and marked with '**' sign.

State	Rainfall trends in mm per year				
	Annual	Winter	Summer	Monsoon	Post monsoon
Andaman & Nicobar	-7.77*	-2.70*	-0.51	-2.93	-1.35
Andhra Pradesh	+1.31	+0.29	+0.35	-0.14	+0.46
Arunachal Pradesh	-3.63	-0.10	No trend	-2.30	-0.83
Assam	-2.96	0.08	-0.56	-2.19	-0.75
Bihar	+1.41	-0.06	+0.59*	+1.11	+0.11
Chhattisgarh	-2.03	+0.02	+0.04	-2.38	+0.06
Delhi	-0.51	+0.16	+0.40*	-0.32	-0.20
Goa	-3.82	No trend	-0.31	-2.61	+0.04
Gujarat	+1.41	No trend	-0.03	+1.27	-0.02
Haryana	+0.45	+0.07	+0.39*	-0.01	-0.23*
Himachal Pradesh	-3.26	-0.18	+0.31	-2.85	-0.21
Jammu & Kashmir	+2.13	+1.88*	-1.07	-0.16	-0.37
Jharkhand	+0.84	-0.13	+0.43	+0.44	+0.03
Karnataka	-0.05	+0.10	-0.41	+0.61	+0.14
Kerala	-1.43	-0.40	-1.15	-2.42	+1.68
Lakshadweep	+3.22	-0.33	-0.44	+1.73	+0.83
Madhya Pradesh	-1.81	-0.06	No trend	-1.74	+0.03
Maharashtra	-0.71	+0.04	-0.15	-0.29	-0.05
Manipur	+1.94	+0.10	+1.63	-0.89	+0.11
Meghalaya	14.68	+0.52*	+2.25	+9.27	+2.04
Mizoram	+0.33	-0.31	+2.80	+7.71	-6.19
Nagaland	-1.86	+0.05	+0.43	-1.69	+0.12
Orissa	+0.69	+0.06	+0.65*	-0.23	-0.83
Punjab	-2.41	+0.09	+0.22	-1.49	-0.13
Rajasthan	+0.04	+0.02	+0.17*	-0.09	-0.04
Sikkim	-3.12	-0.12	-0.83	-1.36	-0.11
Tamil Nadu	+0.80	-0.16	-0.47	-1.35*	+1.49
Tripura	+0.77	+0.11	+1.73	-1.11	-0.55
Uttar Pradesh	-4.42*	-0.22	+0.02	-3.52*	-0.33
Uttarakhand	-1.07	-0.01	+0.86	-1.45	-0.63
West Bengal	+3.63*	+0.16	+1.34*	+1.45	+0.19