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Climate change and its impact on major crops in Gujarat

H. R. PATEL, M.M. LUNAGARIA, B.I. KARANDE, S.B. YADAV, A.V. SHAH, V.K. SOOD and VYAS PANDEY

Department of Agricultural Meteorology, B.A. College of Agriculture, AAU, Anand
Email: hrpatel1954@yahoo.com

ABSTRACT

The projected climatic data (2071 to 2100) as downscaled by PRECIS model for different stations (Anand, Vadodara, Junagadh, Bhavanagar, Bhuj, Rajkot and Kesod) of Gujarat were analysed for climate change impact study on different crops. Results indicated that the annual rainfall during projected period would be 15 to 101 per cent higher than the base line rainfall (1961-90). Maximum temperature would increase by 2.8 to 7.7 ^{0}C, while minimum temperature would increase by 3.8 to 5.2 ^{0}C in different parts of Gujarat. The impact of climate change on different crops (wheat, maize, pearl millet, paddy and groundnut) of Gujarat was studied using InfoCrop and DSSAT models. The results indicated that climate change will adversely affect the yields of different crops. The maximum yield reduction (-61 %) is projected in wheat and lowest in pearl millet (-<8%). Maize during *kharif* season would be more affected (-47 %) than the *rabi* season (-10 %). Similarly pearl millet in summer season will be least affected (-8%) than *kharif* season (-14 %).

Key words: Climate change, trend analysis, base line, PRECIS, projected climate

The increase in temperature in recent past as a consequence of global warming and climate change is a matter of great concern for the climate scientists. Rajeevan (2013) has reported that the annual average temperatures in India have increased over the years with a trend of 0.56^0 C/ 100 years, however, in recent past i.e., since mid 1970s, there is substantial increase in temperatures. Rainfall has also been reported to increase in some part of country, and decrease in other parts with different levels of confidence, as a consequence of climate change. The projected climate change for 21st century as reported by Rupa kumar *et al.* (2006) revealed that PRECIS simulated marked increase in both rainfall and temperature towards the end of the 21st century for India. Air temperature and rainfall show similar patterns of projected changes under A2 and B2 scenarios. West central India shows maximum expected increase in rainfall. Extremes in maximum and minimum temperatures are also expected to increase into the future, but the night temperatures are increasing faster than the day temperatures. Extreme precipitation shows substantial increase over a large area, and particularly over the west coast and west central India.

Pandey *et al*., (2009) had reported slight increasing trend in annual rainfall (2.86 mm per year) in last 50 years at Anand, Gujarat. Lunagaria *et al.* (2012) have reported that there existed large uncertainty in trends of different climatic parameters in Gujarat. At some stations increasing trend, while at other stations decreasing trend was observed. However, warm nights were found to increase in most parts of the state. Detail climatic trend analyses of rainfall and temperature over locations helps in crop management and various adaptation measures for sustainable crop production. This study is aimed to characterize the long – term movement or trend of temperature and rainfall pattern, variation in projected climate and its impact on various crops in the Gujarat state.

MATERIALS AND METHODS

Climate change projection

The climatic data (rainfall, maximum and minimum temperature) of last 30 years considered as base line period (1961-90) of different stations (Anand, Vadodara, Junagadh, Bhavanagar, Bhuj, Rajkot and Kesod) of Gujarat were used for climate change study. The climatic parameters were analysed for trend analysis in different seasons (Winter: December to February, Summer: March to May, Monsoon: June to September and Post monsoon: October to November) in addition to annual basis.

The climate change projection under A2 scenario

Table 1: Model calibration details

Sr. No.	Crop and cultivars	Model	Source
1.	Wheat cv. GW-496 and GW-322	InfoCrop	Patel *et al*., (2007)
2.	Maize (kharif and Rabi) cv. Ganga safed-2 and Guj. Maize-6		Patel *et al*., (2008)
3.	Groundnut(kharif) cv. GG-2 and GG-20	DSSAT v 4.5	Patel *et al*., (2013)
4.	Rice (kharif) cv. Gurjari and Gujrat-17	InfoCrop	Patel *et al*., (2013)
5.	Pearl millet (summer) MSH-226 and GHB-558	DSSAT v 4.5	Yadav *et al*., (2013)
6.	Pearl millet (kharif) MH-1617 and GHB-744		

was derived from PRECIS downscaled model output prepared by IITM Pune in a grid size of 0.4 degree. The climate projection under A2 scenario for period 2071-2100 were considered for climate change study. Since there were gross difference between PRECIS base line (1961-90) daily weather data and actual weather data for the same period, thirty years monthly average of daily weather parameters of base line data was subtracted from corresponding projected A2 scenario data and the difference obtained were used for computing climatic data for projected period using actual observed data. In case of rainfall percentage difference on monthly sum of 30 years average data, between projected output and base line output were used as the correction factor.

Climate change impact on different crops

The PRECIS generated projected daily data of A2 scenario for maximum temperature, minimum temperature, rainfall and solar radiation were used for preparation of weather file. Similarly soil and crop management files were prepared for validation of the model. The validated model for wheat, maize and rice cultivars by InfoCrop and DSSAT for groundnut and pearl millet crops were used for impact analysis (Table 1).

RESULTS AND DISCUSSION

Trend analysis study

The results of trend analysis slope values presented in Table 2 showed that Bhavanagar, and Vadodara show non-significant trend in all the parameters and in all the seasons. Maximum temperature was found to be increasing significantly during winter, monsoon and post-monsoon seasons at Bhuj station and during post monsoon and annual basis at Anand. while at Rajkot it showed significantly negative trend during summer season. The minimum temperature was found to increase significantly in different seasons at Keshod, Junagadh, Rajkot and Anand while it showed decreasing trend at Bhuj. Except Rajkot none of the station showed any significant trend for rainfall. This clearly suggests that during 1961-90 period there was not uniform climatic trend or variation in any of the climatic parameters which support the findings of Lunagaria *et al.* (2012).

Climate projections

The thirty years (2071-2100) mean projected climate are compared with the base line (1961-90) periods (Table 3). Results showed that highest change in projected rainfall (101 %) is at Bhuj whereas the lowest change in projected rainfall (15 %) is at Vadodara. In general locations falling under Saurashtra region are expected to receive higher rainfall (>50 %) as compared to locations of middle Gujarat region (15-37 %). The maximum temperature has been projected to increase between 2.8 to 7.2 ^{0}C at different locations, the maximum increase being at Anand while lowest increase being at Bhuj. Similarly, the minimum temperature has also been projected to increase between 3.8 to 5.2 ^{0}C at different locations. Rupa Kumar *et al.,* (2006) have also reported that the extremes in rainfall, maximum and minimum temperatures are expected to increase in future in different parts of India.

Impact on crop yield

The impact of projected climate on various crops viz., wheat, maize, paddy, pearl millet and groundnut were studied using InfoCrop and DSSAT models and projected climatic data of Anand and Junagadh. Junagadh was selected for groundnut crops while for other crops Anand was selected. The models were run for both the periods i.e., base line (1961-90) and projected (2071-2100). The mean of thirty years were worked out and are compared. The differences in yield are presented in Fig.1. It may be seen that the highest yield reduction (-61 %) was noted under wheat crop followed by *kharif* maize (47 %), *kharif* paddy (32 %) groundnut (24 %) and *kharif* pearl millet (14 %) , rabi maize (10 %) and summer pearl millet (8%). There was not much differences amongst the cultivars. The reduction in yield are mainly attributed to increase in temperature during projected

Table 2: Trend analysis (slope) of selected stations of Gujarat (1961-90)

Weather parameters	Period/Season	Bhavnagar	Bhuj	Kesod	Rajkot	Junagadh	Vadodara	Anand
Maximum temperature	Winter	-0.006	0.031*	-0.002	-0.012	-0.002	0.036	0.030
	Summer	0.004	0.033	-0.012	-0.0001**	-0.012	0.033	0.017
	Monsoon	0.001	0.044*	0.022	0.015	0.022	0.018	0.016
	Post-monsoon	-0.003	0.052*	0.001	0.012	0.001	0.039	0.039**
	Annual	-0.001	0.039	0.021	0.005	0.021	0.031	0.027**
Minimum temperature	Winter	0.007	-0.032	0.009	0.082	0.009	0.021	0.017*
	Summer	0.018	-0.020*	0.007	0.045*	0.007	0.040	0.027**
	Monsoon	0.016	0.014	0.021*	0.037	0.021*	0.017	0.017**
	Post-monsoon	-0.012	-0.019	0.021	0.092*	0.021	0.026	0.025*
	Annual	0.007	-0.016	-0.467	0.064	-0.467	0.022	0.024**
Rainfall	Winter	0.075	-0.032	0.098	-3.28*	0.098	0.000	0.000
	Summer	-0.180	-0.045	-0.019	-0.158	-0.019	0.00	0.000
	Monsoon	-0.296	-1.508	-1.414	0.548	-1.414	10.98	16.51
	Post-monsoon	2.344	-0.216	-0.237	0.443	-0.237	0.000	0.000
	Annual	0.362	-0.449	0.002	-0.613	0.002	10.12	13.25

*: Significant at 5 % level, **: Significant at 1 % level

Table 3: Per cent variation of climate at various locations in relation to base line

Station	Rainfall (mm)			Maximum temperature (^{0}C)			Minimum temperature (^{0}C)		
	Base line (1960-90)	Projected (2071-2100)	Percent change	Base line (1960-90)	Projected (2071-2100)	Difference	Base line (1960-90)	Projected (2071-2100)	Difference
Anand	919	1259	37	29.8	37.5	7.7	19.1	24.3	5.2
Vadodara	980	1127	15	29.7	33.3	3.6	19.3	23.5	4.2
Junagadh	836	1513	81	33.3	37.3	4.0	19.9	24.1	4.2
Bhavanagar	627	953	52	33.9	38.0	4.1	21.3	25.1	3.8
Bhuj	389	782	101	34.7	37.5	2.8	19.4	23.3	3.9
Rajkot	660	1181	79	33.7	37.7	4.0	20.1	24.5	4.4
Kesod	836	1456	74	33.3	37.0	3.7	19.9	24.0	4.1

period. Pandey *et al*. (2007) have reported that increase in temperature by 1 to 3 ^{0}C caused reduction in wheat yield by 8 to 31 per cent. Similarly, Patel *et al*. (2008) reported 5 per cent reduction in maize yield with increase in temperature by 3 ^{0}C. This clearly suggested that under the threat of projected climate change the wheat crop could be severely affected followed maize, paddy and groundnut during *kharif* season. *Rabi* maize and summer pearl millet would be least affected.

CONCLUSION

Climatic trend at selected stations of Gujarat indicated that the annual rainfall during projected period would be 15 to 101 per cent higher than the base line rainfall (1961-90), maximum temperature would increase by 2.8 to 7.7 ^{0}C, while minimum temperature would increase by 3.8 to 5.2 ^{0}C in different parts of Gujarat. The projected climate change will adversely affect the yields of different crops. The maximum yield reduction is projected in wheat and lowest in pearl millet. Maize during *kharif* season would be more affected than the rabi season. Similarly pearl millet in summer season will be affected less than kharif pearl millet.

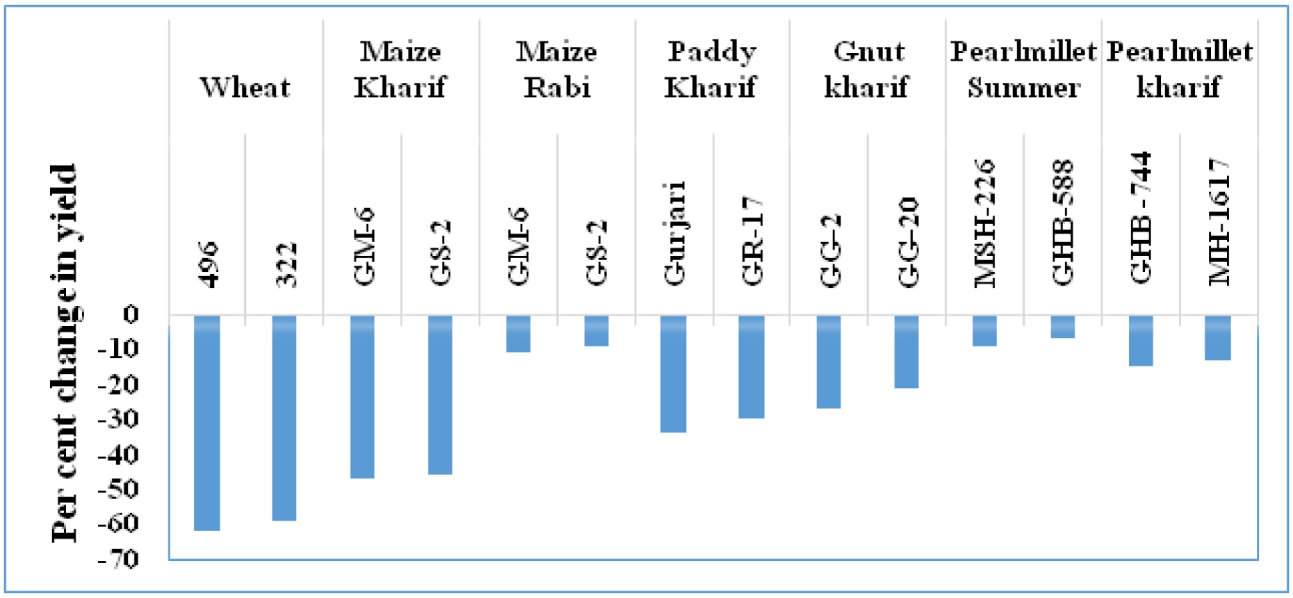

Fig. 1: Per cent change in yield of various crops of Gujarat under projected climate

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