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Research Article

INFLUENCE OF TEMPORAL CHANGES IN CLIMATE VARIABLES ON CROP PRODUCTION IN SOUTH-NORTH SAURASHTRA ZONES OF GUJARAT, INDIA

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ABSTRACT

Objectives: Climate variability and changes have been implicated to have a significant impact on global and regional food production, particularly the common stable crops performance in South-North Saurashtra zone of Gujarat. However, the extent and nature of these impacts remain uncertain.

Methods: In this study, records of crop yield and some climatic variables for a period of 27-year (1988-2014) were used to carry out a comprehensive study of the impact of climate variability on some common classes of food crops in South-North zones of Gujarat with view to determining their responses to the observed varying climatic condition.

Results: Crops differed markedly in their responses to the climate variables. Mean temperature varied with the crop production compared with other food crops. Production of food crops was largely dependent on the seasonal and interannual changes in rainfall. However, a combination of a number of interacting factors with both climatic and nonclimatic components was responsible for the relatively low coefficient of correlation ($r<0.4$) between rainfall and crop yield.

Conclusion: The climate projections for South-North zone of Gujarat by 2025 would have direct and adverse impacts on food production, distribution, and infrastructure and livelihood assets in Gujarat.

Keywords: Climate variability, Crop yield and production, Regional projection, South-North Saurashtra, Gujarat.

INTRODUCTION

The variability of the climate has been a topical issue in a sustainable environment as the crop yield and production is very important to the economy and livelihood of the people of Gujarat. Climate change could have both positive and negative impacts, and these could be measured in terms of effect on crop growth, availability of soil water, soil fertility and erosion, incident of pests and disease.

Temperature throughout Saurashtra is generally high with annual mean of about 27.0°C while diurnal variations are more pronounced than seasonal differences. Rainfall is the key climatic variables, and there is a marked alteration of wet and dry seasons in most areas. During wet seasons, major portion of moisture content and spatial variability is evident in the irregular distribution of rainfall at both short time scale and average condition while the temporal variability tends to be greater in the Northern and Southern Saurashtra zones of Gujarat. The greatest precipitation is generally in the South, where means annual rainfall is more than 1000 mm. Most of the rest of the North receives between 800 and 900 mm of rain per year, and the North West area receives lower total rainfall, generally 500 and 650 mm/year. The regularity of drought periods has been among the most notable aspects of Gujarat climate. These drought periods are indication of the great variability of climate and the most serious effect of which are usually the drier margins of agricultural zones. The high degree of spatial variability of Gujarat rainfall is associated with the dominant rain producing mechanisms with the effect of local features such as topography, vegetation, and land cover type among other. Several factors that directly connect climate change and agricultural productivity include average temperature increase; change in rainfall amount and pattern; rising atmospheric concentration of CO_2, pollution levels such as tropospheric ozone and climate variability/change with the associated extreme event such as drought and flooding [1-3].

The consequences of changes in variability on the ecosystem may be as important as those due to climate change or shift in the mean climate (Hulme *et al*., 1999a; 1999b; Carnell and Senior, 1998). The relationship between climate changes and food security is complex. Many factors influence food security, which means that often the link is not even made between failed crops and changing weather pattern. Changing weather pattern or extreme weather events, such as floods or drought, can have negative consequences for agricultural production [4]. Rural communities dependent on agricultural in a fragile environment are continuously facing an immediate risk of increased crop failure and loss of livestock. Consequently, there is less access to food, which forces the price of the little available food product out of reach of the common man.

METHODS

Secondary data on averages of climatic variables such as temperature (°C), relative humidity (%), and number of wet days from 1988 to 2014 for the South-North Saurashtra zone of Gujarat, were collected from the Agromet cell, Junagadh Agricultural University, Junagadh (Gujarat). The limitation of the crop yield data availability and accessibility influenced the selection of the period for the climatic variability study. The yield/production rates for some common staple food crops (groundnut, pulses, garlic, onion, bajra, cumin, sesamum, wheat, and sorghum) in the region were obtained from the Directorate of Agriculture, Gandhinagar, Gujarat. To adequately examine, the response of different food crops to varying climatic conditions. The annual mean temperature and rainfall as well as number of raining days during both the wet and dry seasons were computed from the observed climatic data. The plots, dependence, and correlation of climatic variables on the crop yields in the South-Northern Saurashtra zone of Gujarat during the special observation period, were determined.

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RESULTS

Table 1 shows that interannual averages of climatic variables in South-North Saurashtra zones of Gujarat from 1988 to 2014. The estimated anomalies of the climate variables indicate that the annual rainfall and number of wet days varied appreciably from the year to year. The trend of the rainfall over the region shows that the more recent years recorded higher annual rainfall compared with the earlier years indicating that the region is becoming wetter. Figs. 1 and 2 depict the relationship between yields of major crops and the climate variables in the study areas. Mean temperature appeared to vary with the garlic crop production compared with other food crops.

Crops did seem to be more dependent on the amount of rainfall (Fig. 2). Fig. 3a-d shows the seasonal variations in climatic variables in the selected region during the special observation period. During the wet season, the years 2007 and 2010 had the highest rainfall with seasonal total of 1353.5 and 1336.1 mm, respectively, whereas the years 1993, 1999, 2000, 2002, and 2012 had the lowest (Table 1). These trends are indication that the rainfall amount was the most variable climatic index in the study area, during the wet and dry seasons. The year 2007 recorded the highest amount of rainfall during both the dry and wet seasons. Consequently, the seasonal changes in relative humidity between the seasons were not apparent (Fig. 3b).

DISCUSSION

The trend of the interannual (Table 1) and seasonal (Fig. 3a-d) variations in climatic variables is indications that the rainfall amount was the most variable climate index in the study area in both the wet and dry seasons. The interannual variability of rainfall was high, and

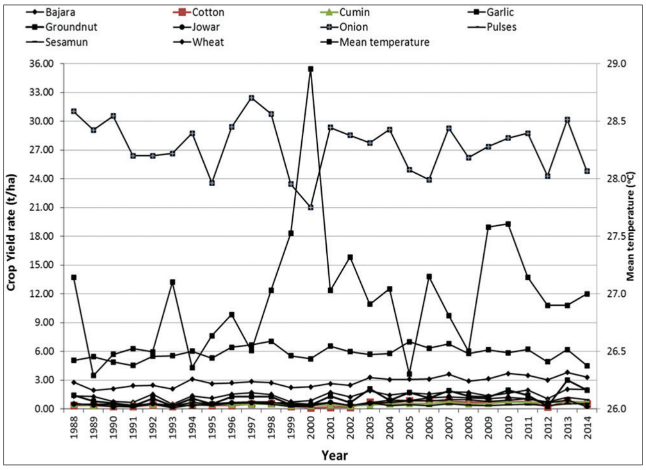

Fig. 1: Crop yields versus temperature (1988-2014) in South-North Saurashtra zone of Gujarat

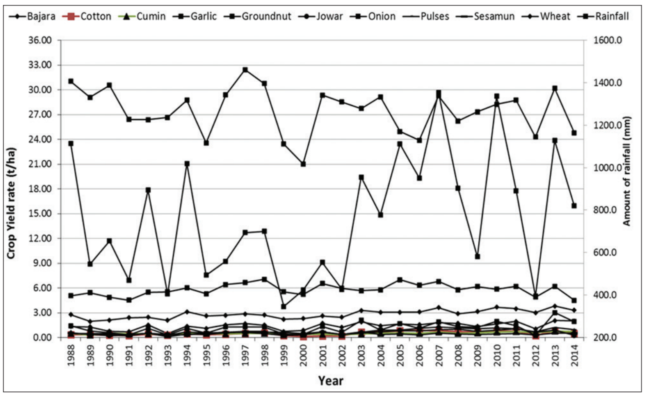

Fig. 2: Crop yields versus rainfall (1988-2014) in South-North Saurashtra zone of Gujarat

this may often result in climate hazards, especially floods, with the devastating effect of on food production and associated calamities and human sufferings.

The productivity of crops grown in tropical regions is highly vulnerable to interannual and seasonal climate variability [5]. The results of the present investigation showed that crop yields and amount of rainfall varied significantly from year to year, and there was a significant relationship between crop yields and temperature or rainfall variability (Figs. 1 and 2). The nonlinearly of the crop yield plots and relatively low correlation coefficients ($r<0.4$) could be attributed to several confounding factors (such as a farm management practices, soil fertility, seed type and quality, and planting period) that were not necessarily climatic.

The region under study produced predominantly onion and garlic than other crops (Figs. 1 and 2). The production trend for garlic was very similar, implying that similar factors affected their production. Dry, wet seasons recorded in 1989 and 2000 might have accounted for the average yield of all the crops except in the years. These establish that all round dry, wet season favors onion production. In climate variables for the decreasing, the sharp temperature and average rainfall range for the year as 1997 that highest yield of the onion production.

The yield for the garlic follows the same trend in the years, but peaks occurring in the years (1998 and 2005), which recorded even rainfall distributions (Figs. 1 and 2). This suggests that similar environmental factors may probably be involved in the grain production. Initially, there was a steady increase in the yield of bajra, groundnut, sorghum, pulses, and wheat from 2007 to 2011, whereas the increasing the highest yield of bajra, groundnut, pulses, and wheat continuous that of sorghum declined. In 1999, the amount of rainfall was low and the yield of bajra, groundnut, pulses, and wheat also decreased. As the amount of rainfall increased in 2007 and 2011, the yield of sorghum also increased. This indicates that increase or decrease in rainfall to large extent plays a major role in determining the yield of crops. 1988 to 2014 years of the climate variables follow that increasing the ascending order of the area, production, and yield of the crops.

However, temperature that increases in 2000, decreasing the yield of bajra, cotton, groundnut, sorghum, pulses, wheat, and onion. While low temperature of the year 1989 that lowering the production of cumin. In contrast, to the crop production within the region, the peaks of cotton and sesamum yields occurred differently, the cotton yield was highest in 2006 with production rate of over 0.90 mt/ha, whereas the yield of sesamum fluctuated frequently (Fig. 2) the sharp temperature in yield of cotton from 2003 to 2006 indicated that other factors not necessarily associated with climate variables (as highlighted earlier) may likely influence its yield and production. The effect of amount of rainfall on the yield of crops could not be clearly established as their yield appeared generally low and fairly constant. Most climate projection over the South-North Saurashtra zone of Gujarat, in general, shows that climate changes may be responsible for declining agricultural productivity in Gujarat will for a longer time, remain a subject of research considering that other influence agricultural productivity. This is because agricultural productivity is socially, economically, and environmentally vulnerable [6].

In conclusion, a reasonable relationship between crop yield and climate variability particularly the temporal changes in rainfall amount has been established. The low computed correlation coefficient ($r<0.4$) for all crop yields with climatic variables implies that crop production may largely depend on combinations of number of interacting factors which are of both climatic and nonclimatic components. Although crop yield could be climate dependent, other variables such as farm management practices. Soil fertility, pests, seed type and quality, and planting period may contribute significantly to variations in crop yield. Inappropriate management practices such as soil compaction during the site clearing and preparation, top soil, litter deposition, burning of

Table 1: Observed interannual mean climate parameters between 1988 and 2014 in South-North zone of Gujarat

Climate parameters								
Year	Temperature (°C)		Rainfall (mm)		Relative humidity (%)		Number of wet days	
	Annual mean	Anomalies	Annual total	Anomalies	Annual mean	Anomalies	Annual total	Anomalies
1988	27.1	0.54	1114.7	331.0	60	1.78	57	16.81
1989	26.3	0.60	545.4	116.6	60	2.31	28	5.92
1990	26.5	0.67	655.1	251.3	61	1.01	33	12.76
1991	26.5	0.48	470.5	61.1	58	0.75	24	3.10
1992	26.5	0.69	894.3	145.5	60	0.78	45	7.39
1993	27.1	0.52	404.7	141.8	57	4.41	21	7.20
1994	26.4	0.52	1018.9	242.3	62	3.96	52	12.30
1995	26.6	0.80	493.7	242.2	59	2.92	25	12.30
1996	26.8	0.69	558.7	127.8	59	1.53	28	6.49
1997	26.5	0.90	694.1	179.2	63	2.41	35	9.10
1998	27.0	0.88	699.9	269.4	61	4.56	36	13.68
1999	27.5	2.11	346.2	98.2	59	5.68	18	4.99
2000	29.0	3.25	424.1	142.8	55	5.89	22	7.25
2001	27.0	0.57	553.6	206.7	57	6.51	28	10.50
2002	27.3	0.88	426.7	153.1	54	5.12	22	7.77
2003	26.9	0.93	955.1	246.4	56	3.47	49	12.51
2004	27.0	0.81	778.1	260.1	60	5.87	40	13.21
2005	26.3	0.55	1110.7	154.0	60	6.24	56	7.82
2006	27.1	0.94	951.3	175.7	61	5.08	48	8.92
2007	26.8	0.80	1353.5	129.4	61	5.61	69	6.57
2008	26.5	0.49	902.9	272.0	61	4.68	46	13.81
2009	27.6	0.49	580.3	171.7	58	5.11	29	8.72
2010	27.6	0.57	1336.1	389.9	61	6.18	68	19.80
2011	27.1	0.47	891.1	207.6	60	4.59	45	10.54
2012	26.9	0.62	395.0	33.0	59	4.50	20	1.67
2013	26.9	0.32	1127.5	298.9	59	1.08	57	15.18
2014	27.0	0.30	820.3	435.7	63	5.99	42	22.13

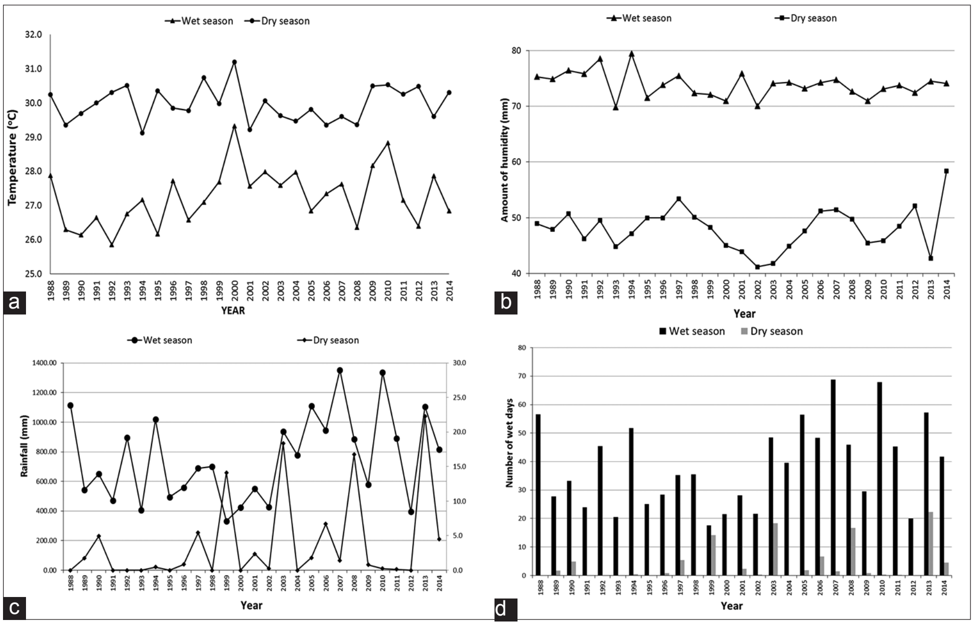

Fig. 3: Seasonal variability in (a) temperature, (b) relative humidity, (c) rainfall, and (d) number of wet days in South-North Saurashtra zone of Gujarat

debris, harvesting methods, and managements of harvest residues [1,7] have been reported to influence crop yield.

In this study, the temperature ranges between the years of 1988 and 2014 were 0.8°C with this rate and magnitude of surface warming, the future of agricultural products particularly crop that respond more quickly to temperature variation within this region may be serious threat. Therefore, specific technologies and management styles may need to be developed to ensure the sustainability of agricultural products.

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