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Research Paper

Impact of climate variability on crop yield in different districts of Gulburga division

■ **LAXMI N. TIRLAPUR AND N.R. MAMLE DESAI**

See end of the paper for authors' affiliations

Correspondence to :
LAXMI N. TIRLAPUR
Department of Agricultural Economics, College of Agriculture (U.A.S.), VIJAYAPUR (KARNATAKA) INDIA
Email : laxmint4424@gmail.com

ABSTRACT : India is mainly an agricultural country. Agriculture being a means of livelihood of almost 58 per cent of the population in the country represents India's most important economic sector. Climate and Agriculture are inextricably linked. Climate change affects agriculture in a number of ways, including through changes in average temperatures, rainfall, climate extremes, changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods; and changes in sea level. Realizing the importance of climate for agriculture production, present study was carried out in different districts of Gulbarga division. Study was based on secondary data collected from DES and one more published source entitled as "Statistical analysis of hundred year's rainfall data of Karnataka" published by M. B. Rajeegowda, Head AICRP on Agro-meteorology project at UAS, Bangalore. Analytical tools such as tabular analysis and multiple regression models were used. Results of the study revealed that, in all the districts namely Bellary, Bidar, Gulburga and Raichur rainfall showed decreasing trend during the period of study from 1983-84 to 2012-13. Maximum range in the magnitude of average rainfall between the driest and wettest years was observed in Bidar district *i.e.*, 332.74 mm followed by Gulbarga, Bellary, Raichur and Koppal. In Bellary district 80.11 per cent and 86.50 per cent of variation in the yield of Jowar and Cotton was explained by the Climatic parameters used in the study. In Gulbarga district 84.60 per cent variation in Jowar yield was explained by the variables such as actual rainfall, maximum and minimum temperature and maximum and relative humidity. In case of Raichur district Sunflower and Jowar yield were highly sensitive to the climate variability because 94.30 per cent and 81.56 per cent variation in the yield of Sunflower and Jowar was explained by the variables under study.

KEY WORDS : Climate variability, Climate change, Deviation, Range, Green house gases

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INTRODUCTION :

India is mainly an agricultural country. Agriculture being a means of livelihood of almost 58 per cent of the population in the country represents India's most important economic sector. Agriculture sector alone represents 13.6 per cent of India's Gross National Product (GNP), plays a crucial role in the country's development and shall continue to occupy an important place in the national economy. It sustains the livelihood of nearly 70 per cent of the population, employs about 51 per cent of the work-force and nearly 10 per cent to export earnings. Climate and Agriculture are inextricably linked. Climate change affects agriculture in a number of ways, including through

changes in average temperatures, rainfall, climate extremes, changes in pests and diseases; changes in atmospheric carbon dioxide and ground-level ozone concentrations; changes in the nutritional quality of some foods and changes in sea level. Climate change will probably increase the risk of food insecurity for some vulnerable groups, such as the poor. It seems obvious that any significant change in climate on a global scale will impact local agriculture, and therefore affect the world's food supply. Considerable studies have been carried out to investigate how farming might be affected in the different regions (Amrit, 2010).

The current climate change is linked mostly to greenhouse gas emissions resulting from human activities. These emissions of anthropogenic origin are by themselves responsible for more than 3/4 of the carbon dioxide (CO_2). The consumption of fossil fuels is by far the most incriminating factor. But we should not forget that changes in land use, including deforestation, occupy second place in term of responsibility for the worldwide increase in greenhouse gas emissions (17% of global emissions). The rise in the concentration of green houses gases was caused primarily by human and industrial activities. The increased agricultural activities and organic waste management are presumed to be contributing to the building up of both methane and nitrous oxide in the atmosphere. However, agriculture in general and Indian agriculture in particular is not contributing significantly to global climatic change.

India's total contribution to global methane emission from all sources is only 18.5Tg per year. Agriculture (largely rice paddies and ruminant animal production) is a major source of CH_4 emission and contributes 68 per cent to it. Since India and China are the major rice producing countries, an international opinion was made that Asia and in particular, India and China are contributing significantly to global warming and they should do something to prevent this phenomenon.

Atmospheric concentration of N_2O is increasing at a rate of 0.22±0.02 per cent per year. But despite its lower concentration and less rapid rise, N_2O is becoming an important GHG, because of its longer lifetime and greater global warming potential than CO_2 (300 times more than that of CO_2 molecule). About 5 per cent of total greenhouse effect can be ascribed to N_2O and it is also responsible for the destruction of stratospheric ozone. Estimates of total nitrous oxides from Indian agriculture are very low due to low soil fertility and lower amounts of fertilizers used in agriculture as compared to the western countries. In India, CO_2 fixation becomes more important, because we use almost 190 million hectare of land for farming. The estimated dry biomass production from agriculture in India is almost 800 million tons every year. IPCC projections for climate change at global level by 2080 are global average surface warming (surface air temperature change) will increase by 1.1 - 6.4 °C, sea level will rise between 18 and 59 cm, oceans will become more acidic, hot extremes, heat waves and heavy precipitation events will continue to become more frequent, there will be more precipitation at higher latitudes and it is likely that there will be less precipitation in most subtropical land areas. Impacts of climate change are adverse. Climate change will make monsoons unpredictable. As a result crop yield per hectare will be hit badly, causing food insecurity and loss of livelihood. Keeping all this in view present study was under taken to analyse the impact of climatic parameters namely rainfall and temperature on agriculture in different districts of Gulbarga division.

MATERIALS AND METHODS :

Study was based on and secondary data. Monthly temperature and rainfall data for a period of about 30 years and 14 years, respectively, were collected from Directorate of Economics and Statistics (DES), Bangalore. For the purpose of assessing the impact of climate change on crop yield for the selected crops of North-Karnataka districts, 14 years data on actual rainfall, maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity were collected from DES and one more published source entitled as "Statistical analysis of hundred year's rainfall data of Karnataka" published by M.B. Rajeegowda, Head AICRP on Agro-meteorology project at UAS, Bangalore.

Selection of crops:

To ascertain the impact of climate variability on crop yield of major dry land crops grown in each district, triennium ending for area under different crops from 2010-11 to 2012-13 was calculated. The crops covering to the extent of 5 per cent to 10 per cent of the gross cropped area of that district will be selected as major crops of that district. Crops such as Jowar, maize, Bengalgram, Groundnut, Sunflower and cotton from Bellary district, Jowar, Tur, Blackgram, greengram,

Bengalgram, soybean from Bidar district, Jowar, Tur, Greengram, Bengalgram, sunflower from Gulbarga district and Jowar, bajra, Tur, Bengalgram, sunflower from Raichur district were selected for the study. Impact of different weather parameters on yield of those selected crops grown in the identified districts were calculated to get results for drawing meaningful conclusions.

In order to study the impact of climate change on the productivity of the selected crops in various districts of Gulburga division, an econometric model of crop production was attempted. These crops were grown under rainfed conditions and any change in climate, particularly rainfall and temperature would affect the productivity of these crops significantly. The following multiple regression model was used to examine the cause and effect relationship between crop productivity and various explanatory variables mentioned below:

$Y=f(X_1, X_2, X_3, X_4, X_5)$

where,

Y= Crop yield on per hectare basis (kg/ha)

X_1= Actual annual rainfall (mm)

X_2=Mean maximum temperature during crop season (^{0}C)

X_3= Mean minimum temperature during crop season (^{0}C)

X_4= Mean maximum relative humidity during cropping season (%)

X_5= Mean minimum relative humidity during cropping season (%)

These weather parameters were affect the crop yield either directly or indirectly in any reasons. So these parameters were selected for analyzing the impact of weather on crop yield.

RESULTS AND DATA ANALYSIS :

Rainfall trend in different districts of Gulbarga division is presented in Fig 1. In all the districts namely Bellary, Bidar, Gulburga and Raichur rainfall showed decreasing trend during the period of study from 1983-84 to 2012-13. But this decring trend was highest in case of Gulburga district followed by Raichur, Bidar and Bellary. These results were in line with results obtained by Shashidahra and Reddy (2012).

Driest and wettest years during the study period from 1983-2012 is presented in the Table 1. Bellary district were experienced rainfall of 324 mm and 799 mm during 1995 and 1996, respectively. These years are the driest and wettest years of Bellary district. Bidar district experienced highest rainfall of 1308 mm during 1995 and least rainfall of 567 mm during 1994. Gulbarga and Raichur districts experienced least rainfall of 471 mm and 358 mm during 2003 and 2011, respectively. Wettest years of Gulbarga and Raichur districts are 1983 and 1998 with rainfall of 1425.9 mm and 921 mm, respectively. Koppal district experienced highest rainfall of 751 mm during 1998 and lowest rainfall of 328 mm during 2003. So 2003 and 1998 were said to be the driest and wettest years of Koppal district. These results were in line with results obtained by Hiremath (2010).

Range of positive and negative (> 50 %) deviation values (mm) for selected districts of North-Karnataka is presented in Table 2. It shows that the maximum range in the magnitude of average rainfall between the driest and wettest years was observed in Bidar district *i.e.*; 332.74 mm followed by Gulbarga, Bellary, Raichur and Koppal. Koppal district witnessed the deviation in the magnitude of average rainfall between the driest and wettest years *i.e.*; 179.70 mm. These results are in line with results obtained by Masato and Nobuo (2013).

Season-wise average maximum and minimum temperatures (degrees centigrade) for the districts of Gulbarga division is presented in Table 3 is done here. Maximum summer temperature was observed in case of Gulbarga followed by Raichur. Because of negative correlation between temperature and rainfall, Raichur and Gulbarga experience more temperature and less rainfall. Average maximum temperature was more in case of Raichur followed by Gulbarga and Bidar.

Table 1 : Driest and wettest years during the period 1983-2012 in selected districts of Gulbarga division

Sr. No.	District	Driest year	Rainfall (mm)	Wettest year	Rainfall (mm)
1.	Bellary	1995	324	1996	799
2.	Bidar	1994	567	1995	1308
3.	Gulburga	2003	471	1983	1425.9
4.	Raichur	2011	358	1998	921
5.	Koppal	2003	328	1998	751

Table 2 : Range of positive and negative (> 50 %) deviation values (mm) for selected districts of Gulbarga division

Sr. No.	District	Average rainfall > 50 % positive deviation (mm)	Average rainfall > 50 % negative deviation (mm)	Range (mm)
1.	Bellary	701.65	472.77	228.88
2.	Bidar	1062.85	730.11	332.74
3.	Gulburga	935.86	619.29	316.56
4.	Raichur	715.37	493.07	222.29
5.	Koppal	659.00	479.30	179.70

Table 3 : Season-wise average maximum and minimum temperatures (degrees centigrade) for the districts of Gulbarga division (1999-2000 to 2012-13)

Sr. No.	Districts	Winter		Summer		Monsoon		Post-monsoon	
		Dec.- Feb.		March-May		June-Sept.		Oct.-Nov.	
		Avg max temp.	Avg min temp.	Avg max temp.	Avg min temp.	Avg max temp.	Avg min temp.	Avg max temp.	Avg min temp.
1.	Bellary	31.79	18.78	35.80	22.91	30.50	21.83	30.17	19.71
2.	Bidar	31.29	16.08	38.82	23.38	31.17	22.45	30.45	19.02
3.	Gulbarga	31.88	16.69	39.93	24.12	31.45	23.02	31.05	21.28
4.	Raichur	31.95	17.72	38.47	24.28	32.74	23.56	31.58	20.69
5.	Koppal	30.82	16.07	36.79	21.98	30.24	20.86	30.10	18.84

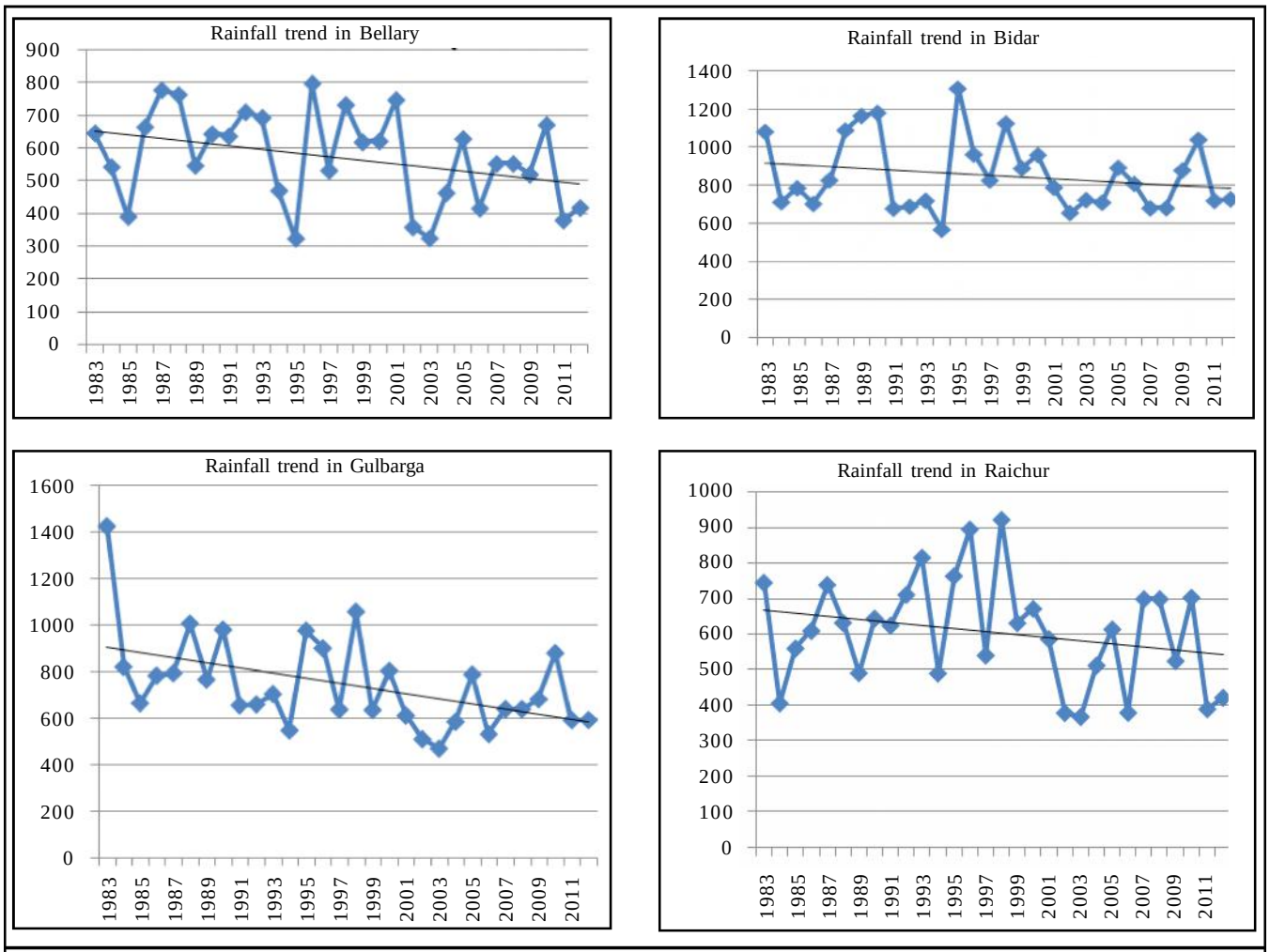

Fig. 1 : Rainfall trend in districts of Gulbarga division

Factors influencing the yield of major crops in selected districts of North-Karnataka :

Variation in yield of Jowar was explained by the selected explanatory variables, out of which, actual rainfall had a highly significant and positive impact on the yield in Bellary district (Table 4). These results were in line with results obtained by Karthick *et al.* (2013). Jowar is best adapted to areas having an average annual rainfall between 45 to 65 cm. Jowar can respond to good moisture supplies so it threw well if rainfall is good. So rainfall had positive impact on Jowar yield. Rainfall and maximum relative humidity were significantly contributed to the yield of Maize. These results were in line with results obtained by Kumar and Sharma (2013). Maize crop is grown in climates ranging from temperate to tropic during the period when mean daily temperatures are above 15°C and below 45°C. Crop tolerates hot and dry atmospheric conditions so long as sufficient water is available to the plant. So rainfall has significant impact on Maize yield (Kavita, 2014). Negative and significant impact of minimum temperature and minimum relative humidity on Groundnut was observed. Rainfall, maximum temperature and minimum relative humidity were had positive and significant impact on Cotton yield in Bellary. Cotton is a warm season (tropical) crop. It can be profitably grown in regions with rainfall of 850-1100 mm, but economic yields cannot be realized in the region with a rainfall less than 500 mm.

In case of Bidar district Jowar, Blackgram, Greengram, Bengalgram, Tur and Soybean were selected as major crops of this district (Table 5). About 36.51 per cent of variation in Jowar yield, 38.98 per cent of variation in Blackgram yield, 18.83 per cent of variation in Greengram yield, 35.97 per cent variation in Bengalgram yield, 43.49 per cent of variation in Tur and 35.97 per cent of variation in Soybean yield was explained by these variables under study. In case of Soybean, minimum relative humidity was significantly contributing to the yield at negative rate. These results were in line with results obtained from Chandrashekhar *et al.* (2009). In Gulburga district (Table 6), variations in the yield of Jowar, Greengram, Bengalgram, Tur and Sunflower was explained by the variables under study to the extent of 84.60 per cent, 49.56 per cent, 33.90 per cent, 27.18 per cent and 40.48 per cent, respectively. In case of Jowar crop, maximum temperature and minimum relative humidity were significantly contributing to the yield in Gulbarga district (Kaul and Ram, 2009). Since Jowar crop requires rainfall of 40 cm. Economic yield was more if rainfall is good.

Table 4 : Estimates of parameters influencing major crops yield in Bellary district (1999-2000 to 2012-13)

Variables	Jowar	Maize	Bengalgram	Groundnut	Sunflower	Cotton
Intercept	41.84	39.04	-54.88	105.51	-7.53	-66.06
Actual rainfall	0.95*** (0.18)	0.72** (0.23)	1.42** (0.49)	0.67 (0.46)	0.43* (0.20)	0.48** (0.22)
Maximum temperature	-1.47 (2.12)	2.15 (3.11)	8.31 (6.80)	-1.73 (5.46)	442 (2.41)	5.29** (2.33)
Minimum temperature	-2.80 (1.64)	-2.04 (2.41)	-6.66 (4.00)	-10.70** (4.23)	-1.07 (1.87)	1.94 (1.30)
Maximum relative humidity	-6.54 (3.87)	12.89** (5.68)	7.02 (5.45)	-1.83 (9.96)	-2.97 (4.40)	6.34 (3.56)
Minimum relative humidity	0.38 (2.38)	4.58 (3.50)	3.75 (3.99)	-13.38** (6.13)	2.81 (2.71)	4.69* (2.43)
R^2	0.8011	0.5828	0.5502	0.6771	0.4886	0.8650

*, ** and *** indicate significance of values at P=0.10, 0.05 and 0.01, respectively

Table 5 : Estimates of parameters influencing major crops yield in Bidar district (1999-2000 to 2012-13)

Variables	Joawr	Blackgram	Greengram	Bengalgram	Tur	Soybean
Intercept	18.76	-4.51	-20.86	-15.41	37.91	54.76
Actual rainfall	0.12 (0.40)	-0.53 (0.53)	-3.94 (0.74)	-0.34 (0.31)	0.46 (0.59)	-0.009 (0.86)
Maximum temperature	-1.51 (3.48)	11.36 (14.36)	15.24 (19.91)	3.01 (2.73)	-4.94 (5.08)	-8.11 (7.44)
Minimum temperature	-2.27 (3.37)	-7.32 (8.12)	-8.33 (11.25)	4.70 (2.64)	-6.65 (4.92)	-6.18 (7.20)
Maximum relative humidity	4.32 (2.87)	3.33 (6.60)	4.82 (9.15)	-1.69 (2.25)	6.05 (4.20)	11.09 (6.14)
Minimum relative humidity	-4.56 (2.91)	-5.00 (6.16)	-5.26 (8.54)	1.53 (2.28)	-5.49 (4.25)	-11.75** (6.21)
R^2	0.3651	0.3898	0.1883	0.3597	0.4349	0.3597

Note: Figure in the parenthesis indicate standard error

*, ** and *** indicate significance of values at P=0.10, 0.05 and 0.01, respectively

Table 6 : Estimates of parameters influencing major crops yield in Gulburga district (1999-2000 to 2012-13)

Variables	Jowar	Greengram	Bengalgram	Tur	Sunflower
Intercept	-31.53	-32.56	0.20	20.82	2.67
Actual rainfall	0.12 (0.13)	0.87 (0.84)	0.27 (0.40)	0.22 (0.37)	0.19 (0.30)
Maximum temperature	3.45* (1.56)	10.02 (11.13)	2.05 (4.81)	0.04 (4.92)	2.70 (4.03)
Minimum temperature	1.34 (1.18)	-3.13 (10.43)	-0.01 (3.66)	-5.67 (4.61)	-0.39 (3.77)
Maximum relative humidity	5.99** (2.26)	12.42 (13.85)	0.94 (6.97)	1.59 (6.12)	0.70 (5.01)
Minimum relative humidity	-1.04 (0.94)	-11.08 (8.00)	-1.72 (2.91)	-1.25 (3.53)	-2.18 (2.89)
R^2	0.8460	0.4956	0.3390	0.2718	0.4048

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 7 : Estimates of parameters influencing major crops yield in Raichur district (1999-2000 to 2012-13)

Variables	Jowar	Bajra	Bengalgram	Tur	Sunflower
Intercept	-72.86	58.50	10.91	67.23	11.50
Actual rainfall	1.06** (0.28)	0.90* (0.43)	0.48* (0.24)	0.05 (0.39)	0.35** (0.11)
Maximum temperature	3.60 (5.17)	7.62 (9.92)	0.57 (4.40)	-10.62 (10.62)	21.90*** (2.65)
Minimum temperature	2.05 (3.90)	-20.01** (8.80)	-0.19 (3.32)	-8.46 (8.18)	-20.12*** (2.32)
Maximum relative humidity	5.59** (2.29)	-1.25 (4.43)	0.95 (1.94)	-1.23 (6.39)	7.98*** (1.18)
Minimum relative humidity	7.38* (1.75)	-3.76 (5.16)	-3.24* (1.49)	1.25 (2.19)	-13.41*** (1.37)
R^2	0.8156	0.6910	0.5889	0.2764	0.9430

Note: Figure in the parenthesis indicate standard error
*, ** and *** indicate significance of values at P=0.10, 0.05 and 0.01, respectively

Impact of climatic parameters on crop yield in Raichur district is presented in Table 7. In Raichur district actual rainfall (0.35), maximum temperature (21.90) and maximum relative humidity (7.98) were significantly and positively contributing to the Sunflower yield. Sunflower is mainly grown under rainfed conditions on a wide range of soils. Under erratic and low rainfall, a rather deep soil with good water holding capacity is required to get economic yield. Therefore rainfall had positive impact on Sunflower growth and development. Minimum temperature (-20.12) and minimum relative humidity (-13.41) were contributing to the yield of Sunflower negatively. Rainfall was significantly contributing to the yield of Jowar, Bajra and Bengalgram. These results were in line with results obtained from Pratap *et al.* (2014). Water requirement of the crop depends on transpiration rate. A plant with greater total leaf area will transpire more water compared to one having less. In case of Bajra and Jowar because of more leaf area transpiration is more and mean while they need rainfall to get good yield.

Authors' affiliations:
N.R. MAMLE DESAI, Department of Agricultural Economics, College of Agriculture (U.A.S.), VIJAYAPUR (KARNATAKA) INDIA

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