

Impact of Climate Variation on Yield of Kh. Jowar and Paddy

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ABSTRACT

The study was undertaken in Akola, Washim, Gondia and Bhandara Districts. The Kh. Jowar and Paddy crop were selected to study the Impact of climate variations on yield of these crops for the year 2001-2015. The data for present study was collected from the Publication of Dept. of Agriculture, Govt. of Maharashtra. The data of rainfall and temperature for these districts were taken from the Meteorological Department Dr. P.D.K.V. Akola.

The following conclusions of the study were drawn in Akola, Washim, Gondia and Bhandara Districts. Rainfall had inconsistency within weeks over the period of 2001-2015 as revealed by C.V. in all four districts. In Akola, Washim, Gondia and Bhandara districts the consistency in minimum and maximum temperature was observed within weeks over the period 2001-2015. In Washim district, rainfall at seedling stage, minimum temperature and rainfall at grain filling stage affected the crop yield of Kh. Jowar during 2001-2015. In Akola district rainfall, minimum temperature and maximum temperature did not affect the crop yield at seedling, flowering and grain filling stage of Kh. Jowar crop during 2001-2015. In Gondia district, minimum and maximum temperature at flowering stage affected the crop yield of paddy during 2001-2015. In Bhandara district rainfall, minimum temperature and maximum temperature did not affected the crop yield at seedling, flowering and grain filling stage of paddy crop during 2001-2015. In Akola district, cotton and other pulses were major crops of the district during 2000-2001 constituting 67.50 per cent of Total cropped area, but now soybean emerged as one of major crop occupying 43.50 per cent of gross cropped area of region. In Washim district, cotton and other pulses were major crops of the district during 2000-2001, constituting 66 per cent of total cropped area. But now area under cotton and kharif Jowar is reduced and soybean emerged as a major crop occupying 66.24 per cent of gross cropped of region. In Gondia and Bhandara districts paddy is major crop.

Key words: Jowar, Paddy, Major crop, Cotton

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INTRODUCTION

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time. Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions. The impacts of climate change are likely to be severe for the countries like India that have limited arable land but heavy dependence on agriculture also have poor technological and financial capabilities for mitigation and adaptation to climate change. In the past four decades (1969-2005), India's surface temperature has increased by 0.3 °C or by 0.08°C per decade. In recent years, the climate change has been accompanied by increased incidence of natural calamities such as droughts, floods, cyclones and heat waves. Such extreme events can cause a drastic decline in the agricultural output, exacerbating the problems of food insecurity and rural poverty in their study in a few eastern states of India have estimated a 24-58 percent decline in household income and 12-33 per cent rise in farm-household poverty in a drought year. The impact of climate variability on agricultural production is important at local, regional, national, as well as global scales. Crop yields are affected by variations in climatic factors such as air temperature and precipitation, and the frequency and severity of extreme events. The present study revealed the changes in temperature and rainfall for a period of 15 years. The changes in rainfall and temperature has a major impact on the yield of crops. It also responsible for the shifting of cropping pattern or cultivation of new crops to suit the changing climatic conditions of the area. Study reports the farmers and field expert to grasp the ongoing changes in the climatic conditions in study area and deciding new cropping pattern, impact of climate change on Sorghum and Paddy which are major crops cultivated in study area and day to day staple food for people.

MATERIAL AND METHODS

The proposed study was undertaken with the aim to study impact of climate variations on

Kh. Jowar and paddy crop, for Kh. Jowar in Akola and Washim district and for Paddy in Bhandara and Gondia district of Maharashtra state. The present study is based on secondary data. The data of area and production of these crops was taken from the Publication of Dept .of Agriculture, Govt. of Maharashtra. The data collected on weekly rainfall and temperature for the Akola, Washim , Gondia and Bhandara district for the years from 2001 to 2015 from the Meteorological Department Dr. P.D.K.V. Akola.

Changes in Temperature and Rainfall

Mean and CV (%) for weekly rainfall and temperature data is calculated for the behavior of Weekly rainfall and temperature in selected district.

SD

$$CV (\%) = \frac{SD}{\text{Mean}} \times 100$$

Where,

CV (%) = Coefficient of Variation

SD = Standard Deviation

Impact of climate variations on yield

Yield (Y) are dependent variable, Rainfall and Temperature at three crop stages, Independent variable. The three crop stages of Kh. Jowar is taken such as seedling, flowering and grain filling stage, And for Paddy such as seedling, flowering and grain filling stage.

$$Y = a + b_1X_{1tmin} + b_2X_{2tmax} + b_3X_{3r} + b_4X_{4tmin} + b_5X_{5tmax} + b_6X_{6r} + b_7X_{7tmin} + b_8X_{8tmax} + b_9X_{9r}$$

Where,

Y = Yield per ha.

a = Intercept

X_{1tmin} = Minimum temperature at seedling stage

X_{4tmin} = Minimum temperature at flowering stage

X_{7tmin} = Minimum temperature at grain filling stage

X_{2tmax} = Maximum temperature at seedling stage

X_{5tmax} = Maximum temperature at flowering stage

X_{8tmax} = Maximum temperature at grain filling stage

X_{3r} = Rainfall at seedling stage

X_{6r} = Rainfall at flowering stage

X_{9r} = Rainfall at seedling stage.

RESULTS AND DISCUSSION**Changes in Weekly Average, Maximum and Minimum Rainfall in Akola District**

The average rainfall maximum minimum rainfall along with CV (%) as a measure of variability for 20 weeks for Akola district are presented in table 1.

The weekly rainfall for 1 to 20 rainfall weeks in Akola district was analysed for statistic average rainfall. It is Minimum and Maximum

rainfall & coefficient of variation in percentage are presented in table. It is revealed from the table that wider variability was observed in all the 20 weeks most of the weeks have zero minimum rainfall while the maximum rainfall over the weeks ranges between 45 to 231.9(mm). The inconsistency within week over the years is revealed by CV (%) ranging between 48.41 to 265.52 % indicating unreliability of average the years.

Table 1. Changes in Weekly Average, Maximum and Minimum Rainfall in Akola District

Akola Rainfall				
Weeks	Mean	CV (%)	MIN	MAX
22	6.47	265.52	0	45
23	15.09	163.28	0	47.30
24	40.29	112.34	0	138
25	26.29	72.63	1.52	59.40
26	48.59	120.10	0	195
27	47.33	109.50	0	144
28	20.28	81.84	0	48.60
29	38.61	48.41	13	68.90
30	63.05	73.86	1.81	89.70
31	60.97	111.26	0.52	185
32	42.63	131.12	4.21	231.90
33	22.44	115.81	0	100.41
34	28.15	86.38	0	69.62
35	29.77	101.17	0	82.12
36	51.86	65.93	0	109.14
37	30.08	139.19	0.60	145.64
38	27.79	118.64	0	104.26
39	17.47	154.65	0	74
40	26.05	133.12	0	103.10
41	4.15	160.63	0	18

Changes in Weekly Average, Maximum and Minimum Rainfall in Washim District

The average rainfall maximum minimum rainfall along with CV (%) as a measure of variability for 20 weeks for Washim district are presented in table2.

The weekly rainfall for 1 to 20 rainfall weeks in Washim district was analysed for statistic average rainfall. It is Minimum and Maximum rainfall & coefficient of variation in percentage are presented in table.

Table 2. Changes in Weekly Average, Maximum and Minimum Rainfall in Washim District

Washim Rainfall				
Weeks	Mean	CV(%)	MIN	MAX
22	4.59	206.66	0	26.50
23	24.07	127.10	0	92.21
24	84.07	107.98	0	284.23
25	37.79	83.88	0	76.84
26	81.89	108.65	0	296
27	62.98	101.15	0	225
28	47.17	91.31	0	106
29	66.41	84.76	12	226.50
30	84.85	86.66	0	182
31	105.29	81.88	0	256.58
32	67.87	142.64	0	391
33	26.19	91.69	0	65

34	60.31	131.87	0	203
35	62.33	101.28	0	204.94
36	51.63	59.21	0	102.62
37	26.82	153.44	0	155.23
38	43.39	104.86	0	127
39	18.91	139.30	0	55
40	30.10	175.40	0	191.21
41	11.57	239.14	0	106.32

It is revealed from the table that wider variability was observed in all the 20 weeks most of the weeks have zero minimum rainfall while the maximum rainfall over the weeks ranges between 26.5 to 391(mm). The inconsistency within week over the years is revealed by CV (%) ranging between 59.21 to 239.14 % indicating unreliability of average the years.

Changes in Weekly Average, Maximum and Minimum Rainfall in Gondia District

The average rainfall maximum and minimum rainfall along with CV (%) as a measure of variability for 20 weeks for Gondia district are

presented in table3. The weekly rainfall for 1 to 20 rainfall weeks in Gondia district was analysed for statistic average rainfall. It is Minimum and Maximum rainfall & coefficient of variation in percentage are presented in table. It is revealed from the table that wider variability was observed in all the 20 weeks most of the weeks have zero minimum rainfall while the maximum rainfall over the weeks ranges between 3 to 220.4 (mm). The inconsistency within week over the years is revealed by CV (%) ranging between 55.76 to 294.55 % indicating unreliability of average the years.

Table 3. Changes in Weekly Average, Maximum and Minimum Rainfall in Gondia District

Gondia Rainfall				
Weeks	Mean	CV(%)	MIN	MAX
22	0.36	265.77	0	3
23	10.01	133.14	0	45.41
24	41.38	143.80	0	186.43
25	33.18	76.85	0	72.61
26	56.80	82.65	0	152.62
27	54.65	73.05	0	136.43
28	63.98	83.09	2.21	169.83
29	62.84	75.62	3.42	179.82
30	112.32	55.76	21.40	220.40
31	84.69	74.90	0	211.40
32	78.95	83.01	16.61	2911
33	67.09	82.08	0	157.81
34	39.07	66.94	0	103.84
35	61.09	96.65	0	184
36	49.81	115.19	0	218.80
37	32.69	156.48	0	150
38	25.31	112.28	0	100.63
39	10.31	172.52	0	64.21
40	15.26	125.58	0	53.61
41	4.16	294.55	0	45.64

Changes in Weekly Average, Maximum and Minimum Rainfall in Bhandara District

The average rainfall maximum and minimum rainfall along with CV (%) as a measure of variability for 20 weeks for Bhandara district are presented in table 4.

The weekly rainfall for 1 to 20 rainfall weeks in Bhandara district was analysed for statistic average rainfall. It is Minimum and Maximum rainfall & coefficient of variation in

percentage are presented in table. It is revealed from the table that wider variability was observed in all the 20 weeks most of the weeks have zero minimum rainfall while the maximum rainfall over the weeks ranges between 18 to 337.2 (mm). The inconsistency within week over the years is revealed by CV (%) ranging between 51.32 to 254.50 % indicating unreliability of average the years.

Table 4. Changes in Weekly Average, Maximum and Minimum Rainfall in Bhandara District

Bhandara Rainfall				
Weeks	Mean	CV (%)	MIN	MAX
22	3.34	194.15	0	18
23	12.09	133.40	0	42.31
24	59.96	145.37	0	315.20
25	41.98	86.75	3.40	124.12
26	99.51	94.41	1.81	235.41
27	72.14	79.16	0	201
28	58.71	83.08	0	151.41
29	98.65	51.32	43.44	238.93
30	93.57	60.97	11.61	181
31	81.07	77.86	0	224.61
32	107.04	68.02	30	293.62
33	85.91	79.05	7.21	258.61
34	68.98	97.92	3	191.21
35	63.77	103.50	0	255.20
36	87.95	104.20	0	337.20
37	45.28	126.25	0	186
38	32.09	96.27	0	109.85
39	20.71	126.68	0	85.84
40	27.22	147.91	0	153
41	3.85	254.50	0	35.83

Contribution of weather parameter in yield of Kh. Jowar in Washim District

Data on minimum, maximum temperature and rainfall at three crop stages was used for regression analysis with yield. In all nine

independent and one dependent variable studied. The coefficient along with standard error and coefficient of determination are presented in the following table 5.

Table 5. Contribution of weather parameter in yield of Kh. Jowar in Washim District

Washim		
Variable	Coefficient	S. Error
Intercept	1164.62	8398.06
X _{1tmin}	-50.17	95.74
X _{2tmax}	-14.00	34.81
X _{3r}	2.60*	1.18
X _{4tmin}	-104.30	290.25
X _{5tmax}	35.97	107.06
X _{6r}	-0.94	2.42
X _{7tmin}	158.57**	57.84
X _{8tmax}	-8.25	59.95
X _{9r}	5.88**	2.38
R ²	0.8137**	

*Significant at 10% ** Significant at 5%

It is revealed from the table that constant of the regression line described 70% yield ,Irrespective of weather effect the major influence in parameter were the rainfall at seedling stage in Kh. Jowar which adversely affect crop yield ,while the minimum temperature and rainfall at crop stage 3rd or at

grain filling stage found to be major yield contributor. All nine variable taken together and explain 81.37% contribution in describing the crop yield. The value of coefficient of determination the rainfall at seedling stage, minimum temperature and rainfall at grain filling stage are the major contributor.

Contribution of weather parameter in yield of Kh. Jowar in Akola District

Data on minimum, maximum temperature and rainfall at three crop stages was used for regression analysis on yield. In all nine

independent and one dependent variable studied. The coefficient along with standard error and coefficient of determination are presented in the following table 6.

Table 6. Contribution of weather parameter on yield of Kh. Jowar in Akola District

Akola		
Variable	Coefficient	S. Error
Intercept	2819.2906	45102.04
X _{1tmin}	92.63	860.2928
X _{2tmax}	-50.349375	168.5275
X _{3r}	9.4345553	17.73775
X _{4tmin}	-156.53536	2898.477
X _{5tmax}	-28.816854	637.6037
X _{6r}	-3.0541948	13.05549
X _{7tmin}	281.90919	393.8847
X _{8tmax}	-105.36892	268.0773
X _{9r}	-0.8748763	14.61461
R ²	0.5023*	

Table gives the regression between yield of Kh. Jowar and weather parameter of (22-41MW) over a period of 15 years. From table is observed that Kh. Jowar yield and weather parameter related to (22-41MW) did not show any significant regression.

Contribution of weather parameter in yield of Paddy in Gondia District

Data on minimum, maximum temperature and rainfall at three crop stages was used for regression analysis with yield. In all nine independent and one dependent variable studied. The coefficient along with standard

error and coefficient of determination are presented in the following table 7. It is revealed from the table that constant of the regression line described 70% yield, Irrespective of weather effect the major influence in parameter were the minimum and maximum temperature at flowering stage in paddy which adversely affect crop yield. All nine variable taken together and explain 66.62% contribution in describing the crop yield. The value of coefficient of determination the minimum and maximum temperature at flowering stage is the major contributor.

Table 7. Contribution of weather parameter on yield of Paddy in Gondia District

Gondia		
Variable	Coefficient	S. Error
Intercept	-51978.807	27095.71
X _{1tmin}	4.14741383	100.5417
X _{2tmax}	123.107262	88.66759
X _{3r}	8.27864749	5.989939
X _{4tmin}	1148.70*	574.4391
X _{5tmax}	229.77**	99.13896
X _{6r}	5.66916789	3.420147
X _{7tmin}	436.142238	556.256
X _{8tmax}	130.187112	132.4781
X _{9r}	0.73632281	2.540686
	R ²	0.6662**

Contribution of weather parameter on yield of Paddy in Bhandara District

Data on minimum, maximum temperature and rainfall at three crop stages was used for regression analysis with yield. In all nine

independent and one dependent variable studied. The coefficient along with standard error and coefficient of determination are presented in the following table 8.

Table 8. Contribution of weather parameter in yield of Paddy in Bhandara District

Bhandara		
Variable	Coefficient	S. Error
Intercept	-9158.7282	11020.02
X _{1min}	-313.52862	220.3224
X _{2max}	-5.8707564	62.26532
X _{3r}	-13.546875	8.674966
X _{4min}	365.477164	365.9348
X _{5max}	-117.18478	155.3428
X _{6r}	6.80406785	4.503248
X _{7min}	587.473782	341.1493
X _{8max}	-3.13029	73.48418
X _{9r}	1.21532551	1.95631
R ²	0.4953*	

Table gives the regression between yield of Paddy and weather parameter of (22-41MW) over a period of 15 years. From table is

observed that Paddy yield and weather parameter related to (22-41MW) did not show any significant regression.

Table 9. Changes in Cropping Pattern in Akola District during 2001-2015(in "00" ha)

CROP	YEARS			
	2001	2005	2009	2015
Cotton	3296	3240	2845	1470
	(41.84)	(39.97)	(40.48)	(27.44)
Kh.Jowar	861	822	465	151
	(10.93)	(10.14)	(6.62)	(2.82)
Tur	734	844	509	501
	(9.43)	(10.41)	(7.24)	(9.35)
Soybean	778	1244	1515	2331
	(9.88)	(15.35)	(21.56)	(43.50)
Other Pulses	2016	1880	1618	822
	(25.59)	(23.19)	(23.02)	(15.34)

Changes in the cropping pattern in Akola district 2001-2015 are presented in Table9.

Cotton and Other pulses were major crops of the District during 2000-2001 constituting 67.50 per cent of total cropped area. In the span of 15 years cropping pattern has changed substantially in the district. The proportion of area under cotton has reduced by 14 per cent.

In case of *kharif* Jowar, its share over gross cropped area has fallen to the level of 2.82 per cent in 2015 from 10.93 per cent in 2001. Soybean crop is emerging as one of the major crops of the region occupying 43.50 per cent of gross cropped area of the region.

Table 10. Changes in Cropping Pattern in Washim District during 2001-2015 (in “00” ha)

CROP	YEARS			
	2001	2005	2009	2015
Cotton	882 (20.35)	678 (13.88)	524 (11.09)	202 (4.51)
Kh.Jowar	663 (15.30)	525 (10.74)	299 (6.33)	100 (2.23)
Tur	401 (9.25)	474 (9.70)	494 (10.45)	523 (11.68)
soybean	833 (19.22)	1851 (37.88)	2264 (47.91)	2965 (66.24)
Other Pulses	1555 (35.88)	1358 (27.79)	1145 (24.23)	686 (15.33)

(Figures in parenthesis are percentages over gross crop area)

Changes in the cropping pattern in Washim district 2001-2015 are presented in Table 10. Cotton and Other pulses were major crops of the District during 2000-2001 constituting 66 per cent of total cropped area. The proportion of area under Tur over gross cropped area is found to be constant for the period 2001-2005

and maintained a level in the neighborhoods of ten per cent. The area of kh.Jowar and cotton drastically decreases. Soybean crop is emerging as one of the major crops of the region occupying 66.24 per cent of gross cropped area of the region.

Table 11. Changes in Cropping Pattern in Gondia District during 2001-2015 (in “00” ha)

CROP	YEARS			
	2001	2005	2009	2015
Paddy	1818 (94.20)	1625 (94.09)	1819 (92.38)	1747 (90.19)
Tur	40 (2.07)	45 (2.61)	54 (2.74)	65 (3.36)
Other Pulses	46 (2.38)	40 (2.32)	61 (3.10)	73 (3.77)
Gram	26 (1.35)	17 (0.98)	35 (1.78)	52 (2.68)

(Figures in parenthesis are percentages over gross crop area)

Changes in the cropping pattern in Gondia district 2001-2015 are presented in Table 11. The District with a single crop domination i.e. Rice with 90.19 per cent of gross cropped area in the year 2015. The cultivation of other pulse

crops is second choice of the farmer of the district. There is very little crop diversification in this district. It is typical case of concentrated cultivation with one or two crops.

Table 12. Changes in Cropping Pattern in Bhandara District during 2001-2015 (in “00” ha)

CROP	YEARS			
	2001	2005	2009	2015
Paddy	1424 (90.13)	1641 (90.31)	1751 (88.26)	1886 (82.54)
Tur	57 (3.61)	72 (3.96)	77 (3.88)	116 (5.08)
Other Pulses	61 (3.86)	79 (4.35)	80 (4.03)	118 (5.16)
Gram	38 (2.41)	25 (1.38)	76 (3.83)	165 (7.22)

(Figures in parenthesis are percentages over gross crop area)

Changes in the cropping pattern in Bhandara district 2001-2015 are presented in table. Cultivation of rice in this district is sole and major constituent of the cropping pattern of the district. This crop occupies around 82.54 per cent of gross cropped area in 2015. Other pulses, Tur and Gram crops are grown in scattered manner covering 17.50 per cent.

CONCLUSIONS

1. In Akola district, rainfall had inconsistency within weeks over the period of 2001-2015 as revealed by C.V. ranging between 48.41 to 265.52 per cent.
2. In Washim district, rainfall had inconsistency within weeks over the period 2001-2015 as revealed by C.V. ranging between 59.21 to 239.14 per cent.
3. In Gondia district, rainfall had inconsistency within weeks over the period 2001-2015 as revealed by C.V. ranging between 55.76 to 294.55 per cent.
4. In Bhandara district, rainfall had inconsistency within weeks over the period 2001-2015 as revealed by C.V. ranging between 51.32 to 254.50 per cent.
5. In Akola, Washim, Gondia and Bhandara districts the consistency in minimum and maximum temperature observed within weeks over the period 2001-2015.
6. In Washim district, rainfall at seedling stage, minimum temperature and rainfall at grain filling stage affected the crop yield of Kh. Jowar during 2001-2015.
7. In Akola district, rainfall, minimum and maximum temperature did not affect the crop yield at seedling, flowering and grain filling stage of Kh. Jowar crop during 2001-2015.
8. In Gondia district, minimum and maximum temperature at flowering stage affected the crop yield of paddy during 2001-2015.
9. In Bhandara district, rainfall, minimum and maximum temperature did not affect the crop yield at seedling, flowering and grain filling stage of paddy crop during 2001-2015.
10. In Akola district, cotton and other pulses were major crops of the District during 2000-2001 constituting 67.50 per cent of total cropped area but during span of 15 years the area under cotton reduced by 14 per cent and soybean emerged as of major crop occupying 43.50 per cent of gross cropped area of region.
11. In Washim district, cotton and other pulses were major crops of the District during 2000-2001 constituting 66 per cent of total cropped area. But during span of 15 years the area under cotton and kh.jowar is reduced by 15.84 and 13.07 per cent respectively and soybean emerged as of major crop occupying 66.24 per cent of gross cropped of region.
12. In Gondia district, with a single crop domination i.e. Rice with 90.19 per cent of gross cropped area in the year 2015. There is very little crop diversification in Gondia district.
13. In Bhandara district, cultivation of rice is sole and major constituent of the cropping pattern. This crop occupies around 82.54 per cent of gross cropped area in 2015.

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