IMPACT OF CLIMATE CHANGE ON JHARKHAND AGRICULTURE: MITIGATION AND ADOPTION

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ABSTRACT:

Jharkhand state, geographically located at 22° 28' N -25° 30' N latitude and 83° 22' – 87° 40' E Longitude with an altitude up to 1142 m above msl and having humid to sub-humid tropical monsoon type of climate, has a number of agro-climatic/physiographic constraints. Undulating terrain, shallow soil depth, low water retentive capacity and poor fertility of soils, fragmented holdings, high intensity (causing severe soil erosion) often erratically distributed (prolonged dry spells) rainfall and very meagre irrigation potential (10-12%) are the most important constraints. Hence, agriculture is more difficult, tedious and challenging here than most other parts of the country. A considerable increase in average monthly maximum temperature and consistent increase in rainfall pattern with high variability, in recent decades, has further enhanced the agricultural problems in Jharkhand. Analysis of more than 40 years data of rainfall and temperature, recorded at Agrometeorological observatory located at Kanke (Ranchi) has revealed an increase in occurrence of extreme weather events with marked change in climate of Jharkhand state. The state is privileged to receive good amount of rainfall almost round the year.The annual average of rainfall has shown an increasing trend over the decades, the period 2001-08 being an exception because of the few drought years in this period.. It increased consistently from 1250.5 mm (1961-70) to 1623.5 mm (1991-2000). The quantitative increase in rainfall may be considered as a positive change in Jharkhand but it was associated with simultaneous increase in variability also (cv: 13% in 1961-70 to 20% in 1991-2000) which increased the level of uncertainty and possibility of intermittent prolonged dry spells. The increase in annual rainfall was mostly confined in the monsoon period. High intensity rainfall, often received in monsoon months, intensify the problem of soil erosion. Uncertainty on the dates of monsoon onset and its withdrawal also puts a great problem before the farmers. A considerable rise in temperature, over the decades, has been recorded in Jharkhand which might be one of the climatological reasons why the productivity has remained stand still over the decades though the total production has increased due to many other scientific efforts. From 1961 onwards the maximum temperature has been found in increasing trend. The increase in temperature, particularly the maximum temperature has been found to have considerable adverse effect on crop performances, more on the rabi season crops.

1. INTRODUCTION

Agriculture in Jharkhand is mainly rainfed and is characterised by undulating terrain, shallow soil depth, low water retentive capacity, poor soil fertility and fragmented holdings with meagre irrigation potential (10-12%). Rainfall and temperature play a decisive role in suitability, adaptability and productivity of crops in a given region. The Intergovernmental Panel on Climate change predicts that during the next decades, billions of people, particularly those in developing countries, will face changes in rainfall patterns that will contribute to severe water shortages or flooding, and rising temperature that will cause shift in cropping pattern and growing seasons.

Impacts of changes in the rainfall (pattern and magnitude) and temperature as well as an increase in extreme events have profound effect on food availability and socio-economic conditions of a region and alternate cropping pattern may be needed to accommodate such changes. It is reported that during the past 100 years, global mean surface air temperature have risen by 0.74^0C and it is projected to rise by 1to 3^0C during this century. Hingane *et.al*., (1985) reported that the Country-wide annual surface air temperature has increased by 0.4 °C /100 years in this century but the rate of increase slowed down in the recent three decades. The monsoon season rainfall was in decreasing trend over east Madhya Pradesh and adjoining areas, North-east India and parts of Gujarat and Kerala (Kumar *et. al*., 2002). Climate change is a global phenomena but the rate of change and its expected consequences is region specific. Hence, the use of indigenous knowledge and local coping strategies has to be taken as a base line and starting point of the adaptation planning.

2. MATERIALS AND METHODS

Trend of rainfall and temperature vary significantly at regional scales and studies are very limited for the Jharkhand region. By recognising the importance of it, the study was conducted at Kanke, Ranchi, located at 23.17° N latitude and 85.19°E longitude with an altitude of 625m above msl. Rainfall, maximum and minimum Temperature (1961-2008) data recorded for the given place were analysed following standard statistical procedures. Trends of rainfall was studied for annual, winter (January to February), summer (March to May), monsoon (June to September) and post monsoon (October to December) seasons for the region. Different varieties of wheat crop were grown in 2008 and 2009, with recommended package of practice, to see the effect of temperature variations on crop performances.

3. RESULTS AND DISCUSSION

3.1 Changes in Rainfall Pattern

On an average Ranchi region receives annual rainfall of 1423.9mm spread over 73 rainy days with 19 % coefficient of variation. The season-wise rainfall distribution indicated that 82 % of annual rainfall is confined within the four monsoon months (June-

September). Summer and post monsoon rain contributes about 8% and 7 %, respectively whereas the least rainfall is received in winter (3%). Variation in annual as well as seasonal rainfall may be considered as a measure to examine climatic variability/change over the region. Inter and intra decadal variability of rainfall (Table-1) revealed that annual and monsoon season rainfalls are more reliable than other seasons. The variability of annual rainfall was relatively high (19%) during the period 2001-2008 than the decade 961-71 (13%). Very high values of rainfall variability in winter (92%), summer (54%) and post monsoon (120%) in the recent years (2001-08) has created a kind of uncertainty for the crops being grown in seasons other than monsoon season. Hence, raising crops in rabi season (post-monsoon) as well as in pre-monsoon seasons requires assured irrigation facilities. Hence, rainwater harvesting during its plenty and its re-use during its scarcity seems to be the only alternative in Jharkhand state. This will be helpful in growing successful crops in rain-scarce periods as well as in giving life saving irrigations to standing crops raised in monsoon season (rain abundance period) in the events of prolonged dry spells.

Seasons	**Rainfall (mm)**					
	1961-70	**1971-80**	**1981-90**	**1991-2000**	**2001-08**	**1961-2008**
Annual	1250.5(13)	1430.0(18)	1430.5(14)	1623.5(20)	1375.4 (19)	1423.9(19)
Winter	40.6(48)	63.8(58)	43.9(64)	43.7(99)	46.6(92)	47.8(72)
Summer	100.8(56)	99.5(44)	132.3(34)	94.9(43)	115.4(54)	108.3(46)
Monsoon	1026.2(16)	1160.9(20)	1156(16)	1371.5(21)	1183.3(21)	1168.6(21)
Post-monsoon	82.9(78)	105.8(76)	98.3(64)	113.3(64)	95(120)	99.2(77)

Table 1: Decadal Variability in Annual and Seasonal Rainfall in Ranchi Region () Figures in Parentheses are cv%

Trends in rainfall on annual and seasonal basis were also worked out decade-wise and are presented in Table 2. The annual rainfall showed an increasing trend over a period of 48 years from 1961 to 2008 for Ranchi region. The incline was at the rate of 5.6 mm/year. Similar trend was noticed in monsoon (5.2 mm/year), summer (0.29 mm/year) and post monsoon (0.13 mm/ year) rainfall but slight decline trend was noticed in winter rainfall (-0.03 mm/year). In recent years (2001-2008) an increasing tendency of annual, winter, summer and monsoon was noticed whereas post monsoon rainfall showed a decreasing trend by at a rate of 22.8 mm/year. Increasing trends for annual as well as monsoon rainfall were also noticed for three decades 1961-70,1981-90, 1991-2000 and in recent years except for the decade 1971-80s.

	Decades					
	1961-70	1971-80	1981-90	1991-2000	2001-08	1961-2008
Annual	+1.6	-15.1	+35.3	+29.7	+20.8	+5.6
Winter	-1.3	+1.9	-3.5	+5.4	+4.5	-0.03
Summer	+8.1	+2.3	+0.7	-4.6	+0.42	+0.29
Monsoon	+7.8	-8.5	+29.8	+28.4	+38.7	+5.24
Post monsoon	-13.0	-11.0	+8.4	+0.48	-22.8	+0.12

Table 2: Rainfall Trends (mm/year) for Decades and the Period 1961-2008

3.2 High Intensity Rainfall and Soil Erosion

Light textured soils of this region having shallow depths are very prone to erosion in case of high intensity rainfall under the undulating terrain conditions. The trend of change in different levels (25-50 mm, 50-75 mm, 75-100 mm and more than 100 mm) of erosive rainfall events in 24 hours have been studied (Table-3) for different decades. It is observed that the frequency distribution of different intensity ranges of erosive events show an increasing trend in number of events over the decade i.e.15.3 (1961-70) to 20.5 (1991-2000) and decreased slightly (18.1) during the recent years 2001-2008. Soil of Jharkhand is very shallow and lands are undulating with varying slops, intensify the extents of soil erosion. It is apprehended that such increase in number of erosive events may worsen the situation by leaving the top fertile soil barren and unproductive.

Decades	**Ranges (mm)**				
	25-50 mm	**50-75 mm**	**75-100 mm**	**>100 mm**	**Total**
1961-70	10.9	3.4	0.5	0.5	15.3
1971-80	11.1	3.7	1.2	0.7	16.7
1981-90	12.3	3.4	1.0	0.7	17.4
1991-2000	13.4	3.8	2.0	1.3	20.5
2001-2008	13.3	3.0	1.0	0.8	18.1

Table 3: Frequency Distribution of Mean Erosive Rainfall (mm) Events in Different Decades

3.3 Monsoon Onset and Withdrawal

Proper planning and scheduling of cropping activities in rainfed areas can effectively be done only when the farmers have some idea of normal date of monsoon onset, its withdrawal and length of the rainy season. A perusal of data in Table-4 reveals that the normal weeks (Standard Meteorological week, SMW) of start and end of rainy season, in this region, are 24th SMW (11-17 June) and 44 SMW (29 Oct -4 Nov), respectively. Normal duration of rainy season is 20 weeks (140 days) and the length of rainy season ranged from 13 weeks (91 days) to 29 week (203 days)

showing a higher value of variability. This type of uncertainty with regard to the duration of monsoon season puts a major limitation, before the scientists and farmers, in choosing right crops and varieties of appropriate duration.

Start of Rainy Season (SMW)				End of Rainy Season (SMW)				Duration of Rainy Season (Week)			
Early	Late	Mean	CV%	Early	Late	Mean	CV%	Max.	Min.	Mean	CV%
23	27	24	4.6	38	52	45	9.8	29	13	21	20.5

Table 4: Start, End and Duration of Rainy Season at Ranchi

3.4 Temperature Rise and its Impact on Crops

The average monthly maximum temperature for the recent years (2001-2006) has been found considerably higher than the average monthly maximum temperature of the decade 1961-1970 (Fig. 1). The maximum rise of 1.21 ^{o}C has been noticed in the month of May followed by Feb (0.82 ^{O}C), Dec (0.76 ^{O}C), April (0.51 ^{O}C), March (0.43 ^{O}C), Jan (0.3 ^{O}C), June (0.15 ^{O}C) and November (0.1 ^{O}C). In previous few years it has been found that the considerable rise in maximum temperature started from 10th of February which is alarming for Rabi crops. This rise in temperature has been reported to cause sterility in wheat crop. It has been analyzed that the years preceded by below normal rainfall coupled with its erratic distribution and prolonged dry spells were the worse victims of temperature rise. In case of coincidence of temperature rise with the flowering stage, the available technology "applying irrigation even if the soil moisture is adequate" is being advised to the farmers to escape the sterility in wheat.

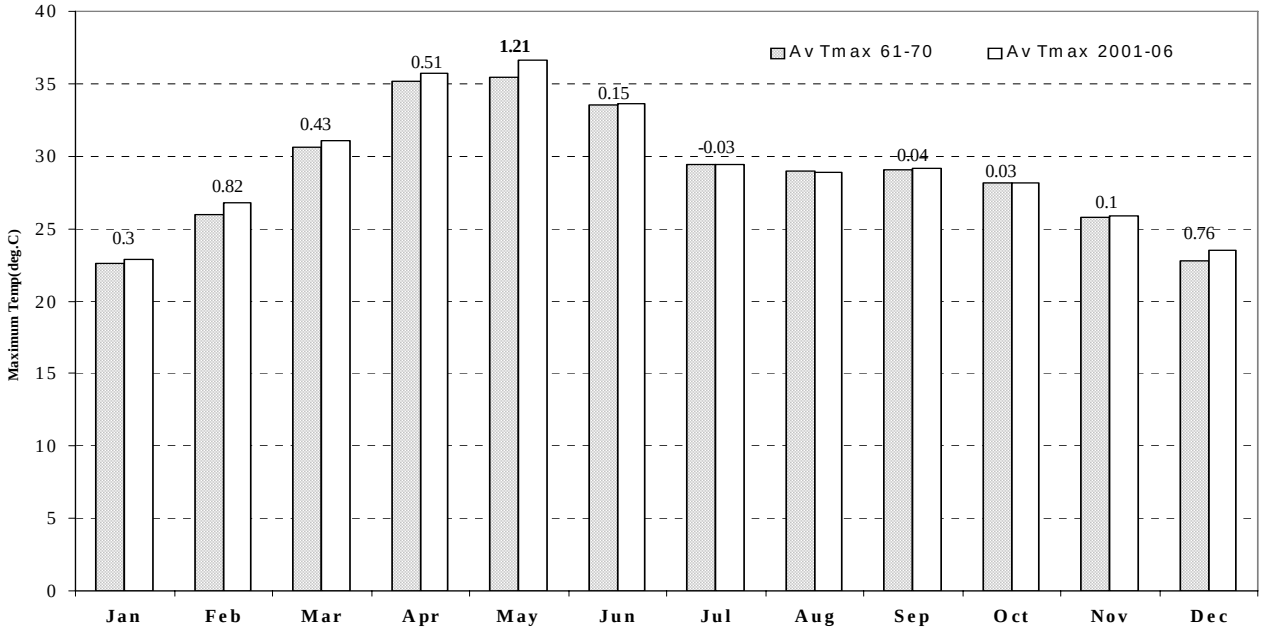

Figure 1. Decadal Change in Average Monthly Maximum Temperature in Ranchi (Jharkhand)

Temperature rise in Jharkhand, due to global warming as well as due to local reasons, has shown its peak effect in summer months this year (2009) when the maximum temperature, in most parts of the state, prevailed 4-7 ^{o}C above the normal, continuously for weeks together coupled with scanty and/or no summer rainfall (unprecedented).

Maximum air temperatures prevailed from 1st January to 25th February in 2008 and 2009 have been illustrated in Fig. 2. It can be seen that the temperature in 2009, from 26th January to 25th February (Boot-Milking stage of wheat crop) was much higher than the temperature in previous year prevailed during the same period. This increase in temperature in 2009 caused advancement in flowering by 12 days, shortening of growing period by 7-8 days and considerable reduction in yield of some varieties (HW2045 & NW 2036) of wheat crop (Table 5.)

Wheat Varieties	Days to Flowering		Days to Maturity		Grain Yield q ha^{-1}	
	2008	2009	2008	2009	2008	2009
HW 2045	84	72	120	112	43.6	30.3
NW 2036	84	72	123	116	43.8	41.7

Table 5: Crop Performances of Wheat Varieties in 2008 and 2009 in Ranchi

CONCLUSION

The changing pattern of Jharkhand climate thus, calls for reviewing the agricultural strategies and research priorities for sustainable agriculture. The most important aspect of the agricultural strategy would be to evolve heat resistant varieties of crops and to add such characters in existing varieties by the plant breeders. Other important aspects would be "the soil and water management" & "weather based crop management" to cope up with the changing climate.

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