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Impact of Climate Change in Palamau Region of Jharkhand, India

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A B S T R A C T

The climate change has become a global concerned and this situation is likely to continue even if concentration of all greenhouse gases is kept constant that is at the level of 2000 AD. The Palamau region of Jharkhand is characterized and well known for its climatic variability. Therefore impact is significant in terms of climate change. The climate of Palamau region has now been shifted from sub- humid to semi-arid and thus agricultural activity has been greatly affected. The analysis shows that the gap between maximum and minimum temperature has widen due to increase in maximum temperature and decline in minimum temperature. The temporal analysis indicates that evaporation and RH (daily) has increased during recent years, and similarly the water deficit has also increased during the same years. In these circumstances there is need to re-orientation of planting time of crops particularly wheat and chickpea, selection of short duration and drought tolerance varieties and crop diversification to mitigate the problems arised due to climate change.

Introduction

There is no doubt that climate is changing and it will go on changing which is a great threat to agriculture and ecology. Even if the concentration of all greenhouse gases is kept constant at the level of 2000 AD a further warming of about 0.1ºC per decade may be expected (Meena *et al.*, 2009). The CO_2 is one of the major greenhouse gases triggering the increased global warming and it is high time that its level should be drastically curtailed before the situation goes beyond control. The climate of Palamau region has now shifted from sub- humid to semi-arid, which is characterized by enough moisture availability to the crop having less than 200 growing season days and < 1000 mm of rainfall having steppy type (dry, grassy, treeless uncultivated area) of vegetation which ultimately affecting the agriculture of the region.

This article presents a vision that how the climatic problems in agriculture can be addressed and sorted out in the changing scenario and it is based on information in Palamau region of Jharkhand. Palamau region lies between 23.5^0 to 24.25^0N and 83.5^0 to 84.04^0E. This study may helps in understanding the impact of climate change on the nature of climate, temperature, evaporation, water balance and humidity of this region so that suitable cropping system, contingent crop planning may be designed for better crop yield and to explore possibility of crop diversification in the changing scenario.

Materials and Methods

The data recorded at Zonal Research Station, Chianki, Palamau has been used for the analysis. The average annual, seasonal and monthly temperature, evaporation, water balance and humidity have been presented and the comparison has also been done.

The changing nature of climatic classification for understanding its pattern and ecological condition so that estimation of agricultural potential may be done by the using formula as suggested by Thornthwaite. This formula is based on PE index which are:

PE index (precipitation of effectiveness index) = P / E X100

Where,

P = annual precipitation
E = annual evaporation

Based on the PE index the Thornthwaite classified the climate into five groups as shown below-

Symbol	Humidity province	PE index
A	Wet	128 and above
B	Humid	64-127
C	Sub-humid	32-63
D	Semiarid	16-31
E	Arid	Less than 16

Results and Discussion

Rainfall pattern

According to Sah *et al.,* (2008) the drastic reduction in annual rainfall during last ten years (1997-2007) was observed. It has reduced to 830.4mm as against to1304.4mm (1958-67) and 1467.9mm during 1968-77 (Fig. 2).

Impact of change in nature of climate

The study clearly revealed that the climate of Palamau region has changed from sub – humid to semi-arid. This remarkable change is due to impact of climate change. During 1976-85, PE index was 41.4 whereas it has been reduced to 26.5 during 1986-2003 periods (Table 1).

Temperature

A rise in mean annual maximum temperature by 2.9^{o}C during 1981-2003 has been observed. Similarly the mean annual minimum temperature has also reduced by 3.6^{o}C. Thus the gap between mean annual maximum and minimum temperature has been widen (Table 2). The mean maximum temperature for all months has gone up whereas the mean minimum temperature for months has been reduced. The highest rise in mean maximum temperature has recorded in the month of May (4.7^{o} C) and the maximum decline in mean minimum temperature has recorded in the month of November (-6.2^{o}C) (Table 3). This is a typical example of impending impacts of climate change.

The study also revealed that there is 4.6^{o}C increase in maximum temperature during February month which is very important for wheat crop. The high temperature, even for short period affects the crop growth in wheat by reducing the growth of shoots and in turn reduces root growth. The higher temperature during booting stage resulted in pollen abortion. In case of wheat the temperature higher than 27^{o}C causes under development of anthers and loss of viability of pollen resulting reduction in yield of wheat.

The higher temperature (39.4^{o}C) during March and April are causing the forced maturity in wheat and chickpea whereas the low temperature lesser than 10^{o}C are affecting

the flowering and pod initiation stage in chickpea resulting in poor pod set and ultimately the yield is reduced.

Evaporation

Temporal analysis showed that the mean annual evaporation has increased drastically during 1986-03. It was 4170.6mm during 1986-03whereas during 1976-85 it was only 2899.0mm meaning thereby there is1271.8mm (43.9%) increase in mean annual evaporation during 1986-2003. Similarly during the same period 92.4mm (7.7%) lesser amount of mean rainfall was also observed (Table 4).

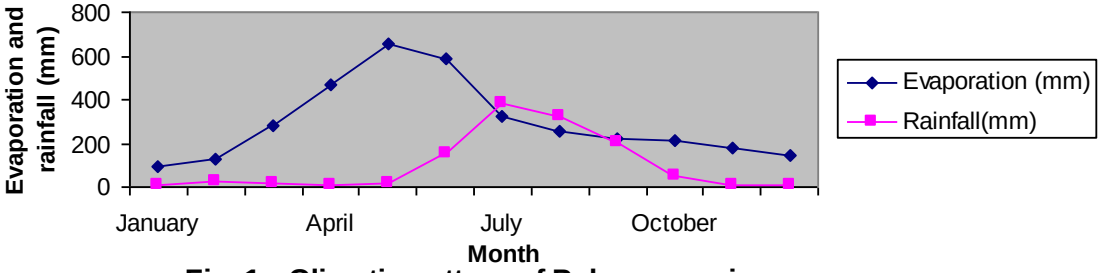

Fig. 1a:Climatic pattern of Palamau region

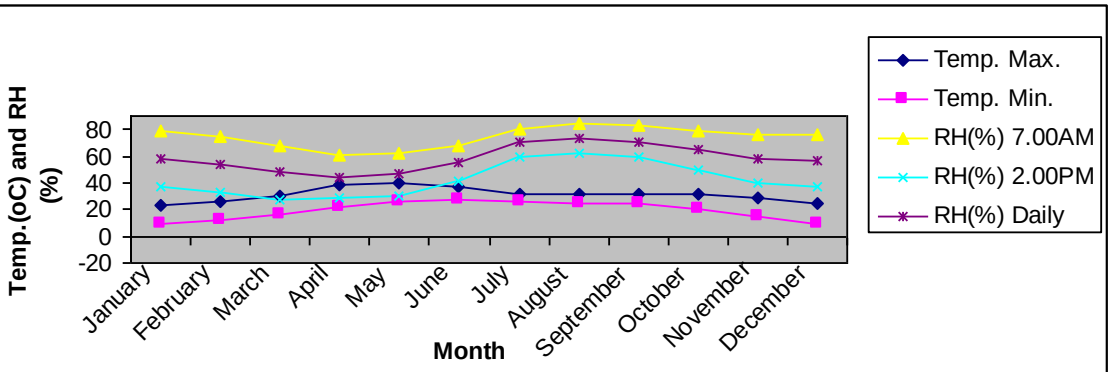

Fig. 1 (b):Climatic pattern of Palamau region

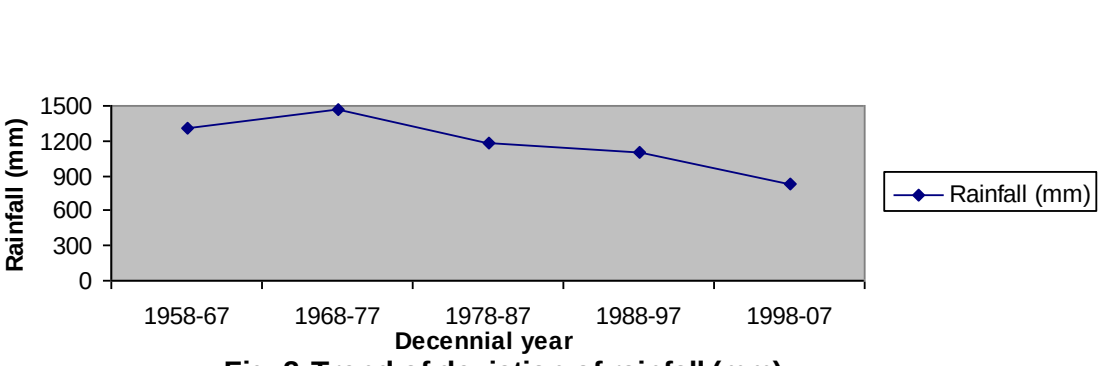

Fig. 2:Trend of deviation of rainfall (mm)

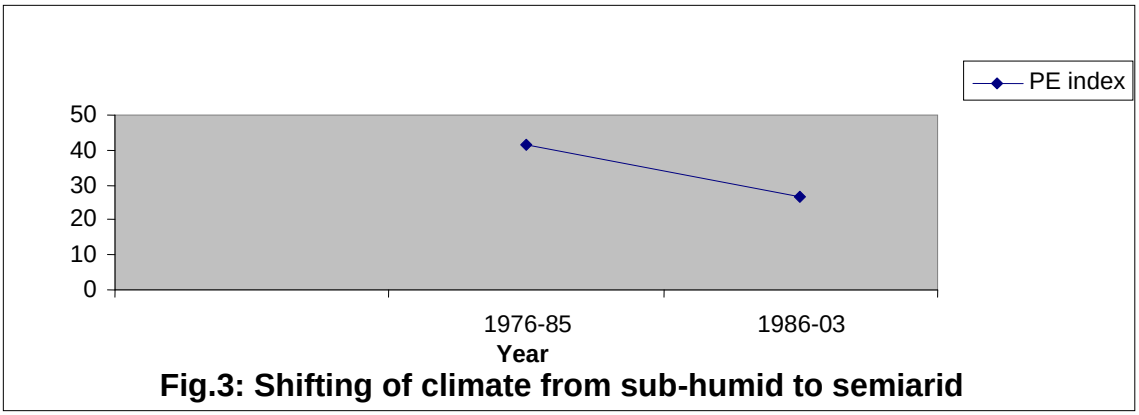

Fig.3: Shifting of climate from sub-humid to semiarid

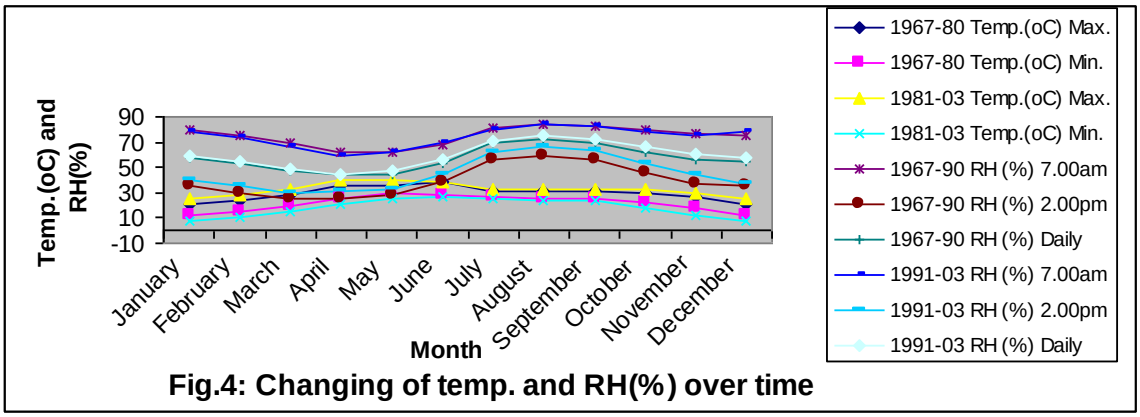

Fig.4: Changing of temp. and RH(%) over time

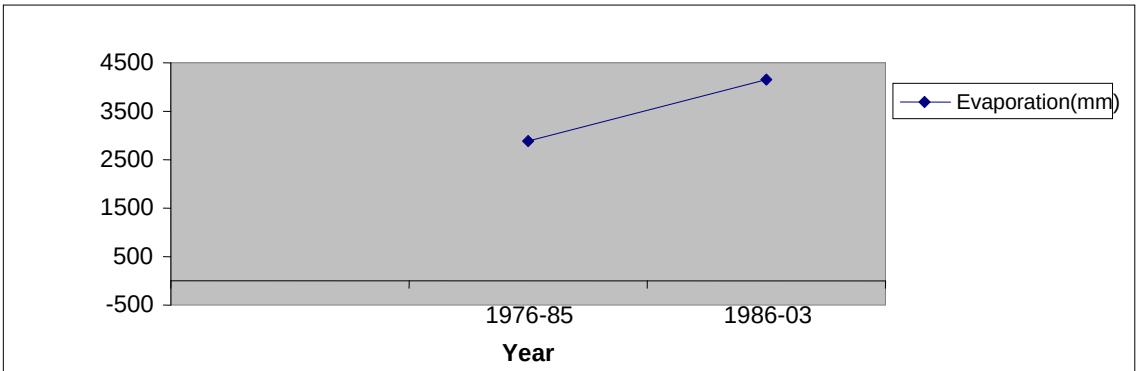

Fig.5: Changing of evaporation (mm) over time

Table.1 PE index

Year	Evaporation(mm)	Rainfall(mm)	PE index
1976-85	2899	1199	41.4
1986-03	4170.6	1107	26.5

Table.2 Changing in annual temperature (^{O}C)

Temperature(^{o}c)	1967-80	1981-03	Normal	Av. Difference between 1981-03 and 1967-80
Max.	29.4	32.3	31.2	2.9
Min.	21.6	18.0	19.4	-3.6
Gap between max. and min. temperature	7.8	14.3	11.8	

Table.3 Changing in monthly temperature (^{O}C)

Month	Temperature(^{o}c)							
	1967-80		1981-03		Normal		Av. Difference between 1981-03 and 1967-80	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	20.3	11.8	24.7	7.2	23.1	9.0	4.4	-4.6
February	23.2	14.8	27.8	10.4	26.0	12.1	4.6	-4.4
March	28.4	19.3	32.1	14.9	30.7	16.6	3.7	-4.4
April	35.8	24.8	39.5	20.4	38.1	22.1	3.7	-4.4
May	35.8	29.0	40.5	25.0	39.9	26.5	4.7	-4.0
June	38.8	28.5	38.9	26.5	36.8	27.3	0.1	-2.0
July	30.8	26.2	33.0	24.7	31.3	25.4	2.2	-1.5
August	30.9	25.8	32.5	23.3	31.9	25.0	1.6	-2.5
September	31.1	25.3	32.3	23.9	31.9	24.4	1.2	-1.4
October	29.9	22.7	32.2	18.6	31.4	20.2	2.3	-4.1
November	26.2	18.2	29.2	12.0	28.1	14.4	3.0	-6.2
December	21.6	12.4	25.4	8.0	23.9	9.7	3.8	-4.4

Table.4 Annual and Seasonal distribution of evaporation (mm) and water balance (mm) over time

Season	1976-85			1986-03		
	Evaporation (mm)	Rainfall(mm)	Water balance(mm)	Evaporation (mm)	Rainfall(mm)	Water balance(mm)
Annual	2899	1199	-1700	4170.6	1107	-3063.6
Monsoon	1115.7	1011.6	-104.1	1656.3	922.9	-733.4
Post monsoon	386.4	69.8	-316.6	679.7	58.0	-621.7
Winter	183.4	52.0	-131.4	259.2	24.0	-235.2
Summer	1213.0	66.1	-1146.9	1597.3	31.8	-1565.5

Table.5 Monthly distribution of evaporation (mm) and water balance (mm) over time

Month	1976-85			1986-03		
	Evaporation(mm)	Rainfall(mm)	Water balance(mm)	Evaporation(mm)	Rainfall(mm)	Water balance(mm)
January	80.6	20.9	-59.7	100.6	9.4	-91.2
February	102.8	31.1	-71.7	158.6	14.6	-144.0
March	235.9	16.5	-219.4	331.3	10.8	-320.5
April	418.1	22.8	-395.3	518.2	5.2	-513.0
May	560.0	26.8	-533.2	747.8	15.8	-732.0
June	493.0	142.1	-350.9	674.7	167.3	-507.4
July	294.8	356.8	-56.0	358.3	286.9	-71.4
August	175.2	289.1	-113.9	329.9	286.2	-43.7
September	152.7	223.6	-70.9	293.4	182.5	-110.9
October	162.6	53	-109.6	261.3	37.4	-223.9
November	135.0	9.2	-125.8	217.7	9.2	-208.5
December	88.8	7.6	-81.2	200.7	11.4	-189.3

Table.6 Comparison of annual and seasonal humidity (%)

Time / Year		7.00am	2.00pm	Daily
1967-90	Annual	74.6	39.4	57.0
	Winter	77.4	32.7	55.0
	Summer	64.3	26.3	45.3
	Monsoon	79.1	52.9	66.0
	Post monsoon	76.9	39.2	58.0
1991-03	Annual	74.0	45.0	59.5
	Winter	76.3	37.3	56.8
	Summer	62.5	31.4	47.0
	Monsoon	78.8	59.0	68.9
	Post monsoon	77.3	45.0	61.2
Normal	Annual	74.3	42.6	58.4
	Winter	77.0	34.8	55.9
	Summer	63.7	28.7	46.2
	Monsoon	79.0	55.8	67.4
	Post monsoon	77.1	44.8	61.0

Table.7 Comparison of monthly humidity (%)

Month	Time	1967-90	1991-03	Normal	Av.difference in daily humidity between 1991-03 and 1967-90
January	7.00am	79.4	78.9	79.2	
	2.00pm	34.9	39.4	37.0	
	Daily	57.2	59.2	58.1	2.0
February	7.00am	75.4	73.7	74.8	
	2.00pm	30.4	35.1	32.6	
	Daily	52.9	54.4	53.7	1.5
March	7.00am	69.2	66.8	68.4	
	2.00pm	25.3	29.9	27.5	
	Daily	47.3	48.4	48.0	1.1
April	7.00am	61.9	59.0	60.9	
	2.00pm	25.5	31.1	28.1	
	Daily	43.7	45.0	44.5	1.3
May	7.00am	61.7	61.7	61.7	
	2.00pm	28.2	33.2	30.6	
	Daily	45.0	47.5	46.2	2.5
June	7.00am	67.8	68.8	68.1	
	2.00pm	38.9	44.8	41.6	
	Daily	53.4	56.8	54.9	3.4
July	7.00am	81.2	80.4	80.9	
	2.00pm	56.7	61.9	59.2	
	Daily	69.0	71.2	70.1	2.2
August	7.00am	84.3	83.7	84.1	
	2.00pm	59.4	66.2	62.6	
	Daily	71.9	75.0	73.4	3.1
September	7.00am	83.0	82.2	82.7	
	2.00pm	56.6	63.2	59.7	
	Daily	69.8	72.7	71.2	2.9
October	7.00am	79.4	78.9	79.3	
	2.00pm	45.4	53.5	49.2	
	Daily	62.4	66.2	64.3	3.8
November	7.00am	76.6	75.5	76.2	
	2.00pm	36.9	44.3	40.4	
	Daily	56.8	59.9	58.3	3.1
December	7.00am	74.7	77.5	75.7	
	2.00pm	35.3	37.1	36.5	
	Daily	55.0	57.3	56.1	2.3

The result revealed that evaporation has increased in all seasons during 1986-2003. It has increased from 1115.7 to 1656.3, 386.4 to 679.7, and 183.4 to 259.2 and 1213.0 to 1597.3mm during monsoon, post monsoon, winter and Pre monsoon season, respectively (Table 4). Evaporation has also been increased in all the months (Table 5).

Impact on water balance

The annual water deficit has increased during 1986-2003(3063.6mm) in comparison to 1976-85(1700mm). All seasons and months also received the lesser amount of rainfall than ET and creating water deficit. The seasonal and monthly water deficit has also been increased during 1986-2003 in comparison to 1976-85 (Tables 4 and 5).

Humidity

The normal value of annual humidity at 7.00 am and 2.00 pm and daily is 74.3, 42.6 and 58.4, respectively. During 1991-2003 daily humidity has increased by 1.1% in comparison to its normal value and by 2.5 % in comparison to value during 1967-90 (Table 2). The humidity (daily) has also been increased during 1991-2003 in comparison to 1967-90 in all seasons. It raised from 55.0, 45.3, 66.0 and 58.0 to 56.8, 47.0, 68.9 and 61.2 % during winter, pre monsoon, monsoon and post monsoon season, respectively.

During 1991-2003 it has also increased by 0.9, 0.8, 1.5 and 0.2% during winter, pre monsoon, monsoon and post monsoon season, respectively in comparison to normal value (Table 6). The analysis showed that humidity at 7.00am reduced in all months except May, June and December month whereas humidity at 2.00pm increased in all months during 1991-2003 in comparison to 1967-90 (Table 7). The daily humidity increased in all months (Table 7). Therefore increase in RH may enhance the incidence of insect-pest and disease. The high RH favours easy germination of fungal spores on the leaves of plant whereas under high humidity the grain yield of maize, wheat is decreased due to adverse effect of RH on pollination and high incidence of pests. Similarly increase in RH during panicle initiation to maturity is increased the yield of sorghum.

Changing climate in the Palamau region of Jharkhand have brought forth myriad new problems and new questions, the solutions to which will be generated by combining farmers, ingenuity, new technologies and several trial-and-error efforts. There is need to re-orientation of planting time of crops particularly of wheat and chickpea, selection of short duration and drought tolerance varieties, inclusion of new cropping system and crop diversification. Similarly there is need to ensure collective action at the personal, corporate and political levels by improved energy efficiency, alternative energy sources, forest conservation and eco-friendly

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