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ANALYSIS OF EXTREME WEATHER EVENTS AT MORENA DISTRICT OF MADHYA PRADESH, INDIA

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ABSTRACT

Climate change is likely to intensify the variability of weather patterns, leading to a rise in extreme seasonal aberrations. The extreme weather events like heat waves, cold waves and frost have great influence on agriculture productivity. These events have negatively impact on crop production and farmers' livelihood. The prediction of magnitude, frequency, timing and duration of extreme weather events in the changing scenario of climate can be supportive towards adaptation of suitable strategies to mitigate its adverse effects on agriculture and socio-economic aspects. The study of occurrence of significant climatic events and their trend analysis were done by utilizing daily maximum temperature, minimum temperature for Morena district which lies in Gird Agroclimatic zone of Madhya Pradesh for the period of 30 years (1984-2013) with the IMD criteria. The study revealed that heat waves varied with annual time scale. The maximum number of heat waves was observed in the year 2010 (57). The 12.4 average annual heat waves were observed during the period 1984-2013. About 4 heat waves could be expected in the month of June. An increasing trend of heat waves was noticed and pointed towards rising of maximum temperature over the region. The cold waves were also exhibited variability. The maximum number of cold waves was observed in the year 2007-08 (20). On an average 5.8 cold waves were observed per year during the period 1984- 85 to 2012-13.The trend analysis revealed that cold waves were becoming less frequent. On an average, 9 frost events per year could be expected. The decreasing trend of frost events was noticed at annual time scale. There is a need for combining disaster reduction, natural resource management and climate change adaptation to reduce vulnerability and enhancement of resilience. Changes in technology and agricultural practices will help to create a society better able to survive the impacts of climatic extremes.
Keywords: Agricultural planning, cold wave, frost, heat wave, risk.

Introduction

Indian agriculture is particularly vulnerable to climate change. The key characteristics of agriculture that could influence its vulnerability to climate change are the high level of subsistence agriculture with small land holdings, majority of rain-fed agriculture, frequent occurrence of extreme weather events and the wide variation in agricultural productivity across the country. Climate change will affect food security through its impacts on components of global, national and local food production systems, which is projected to affect food availability, stability of food supplies, access to food and food utilization. India being mainly an agricultural country, the economy purely depends on the vagaries of the weather and in particular the extreme weather events. Extreme weather events such as heat and cold waves, frost, heavy rainfall and flood etc. are in fact hazardous weather. In past 50 years, India had lost assets of more than Rs 65000 crore and loss of more than 75000 human lives due to floods alone (Attri and Tyagi, 2010 a). The heat wave in 1995 and 1998 and cold wave in 2003 is matter of concern for scientists and planners resulted into partial loss in yield and sometimes complete crop failure and hence reduced income to farmers (De *et al.*, 2005). The yield reduction in winter crops like wheat, mustard and vegetables due to abnormally high temperatures in the month of March 2004 has been reported by Samara and Singh (2004). Episodic heat waves can reduce yields, particularly when they occur during sensitive developing stages of the crops, such as the reproductive phase which increases sterility (Moriondo *et al.*, 2011). The higher temperature caused forced maturity which brought down seed productivity of broccoli, carrot, radish and turnip by 10–15% in Himachal Pradesh. Coconut, banana, cardamom, black pepper and cashew crops were affected due to heat wave-induced lower humidity and soil moisture in Kerala (Singh, 2016). During December 2002 to January, 2003 daily maximum and minimum temperatures at several places in north India remained un-usually below the normal continuously for 3-4 weeks. As a consequence of such phenomena, about 600 ha of orchards of mango and litchi were severely damaged in the Shiwalik belt of Punjab. The extent of damage varied from 40-100 per cent in mango to 50-80 per cent in litchi with reduced fruit size and poor quality in guava, ber and kinnow (Samra *et al.*, 2003). Crop yields in the cold wave year of 2002–2003 were reported to be lowered by 10–42% in wheat, 25–30% in gram and 50–70% in mustard compared to the previous normal year of 2001–2002 at Agra. Similarly, tomato, potato, peas, papaya crops were severely damaged during 2005–2006 and 2007–2008 due to cold waves in the northern states of India (Singh, 2016). Increasing frequency of extreme weather events are expected to be the main reasons for reducing regional water availability and impacting hydrological cycles of evaporation and precipitation, water run-off and erosion. Adaptation strategies to climate change will have to be based on sustainable agriculture practices and coping with the impact of climate change on agriculture will require careful management of resources like soil, water and biodiversity. In the light of significance of extreme events in relation to agriculture, the study of extreme events has been carried out at Morena district of Madhya Pradesh.

Materials and Methods

The data on daily maximum temperature and minimum temperature were obtained from agriculture observatory, Zonal Agricultural Research Station at Morena district for the period 1984-2013. The number of events with heat wave, cold wave and frost conditions along with trend analysis were done by utilizing daily maximum and minimum temperature with the IMD criteria. The IMD defines heat wave based on departure of maximum temperature from its normal. If the normal maximum temperature of plain area is > 40° C then departure of temperature 4 to 5 °C above normal is called heat wave. If the normal maximum temperature of plain area is ≤ 40° C then departure of temperature 5 to 6 °C above normal is called heat wave. Similarly if normal minimum temperature of an area is <10° C then departure of temperature -4 to -5 °C from its normal is called as cold wave. Similarly if normal minimum temperature of an area is ≥10° C then departure of temperature -5 to -6 °C from its normal is called as cold wave. Frost generally occurs when the grass minimum temperature falls to nearly 0°C. It has been found that on an average, grass minimum temperature reaches 0°C when minimum temperature in the screen is 3.5°C. Therefore a day having minimum temperature ≤3.5°C has been categorized as frost day (Bhan and Attri, 2007). This relationship has been used for computation of frost events.

Result and Discussion

Heat waves

The data on heat wave conditions along with its different spans of occurrence are presented in Table 1. The 12.4 average annual heat wave events were observed during the period 1984-2013. A considerable higher numbers of days with heat wave conditions were observed in the years 1995, 2000, 2002, 2010, 2012 and 2013. On an average, considerable higher heat wave events were found in June-July than other months. The average 4.2 events of heat waves were observed in the month of June and 4.5 events of heat waves were observed in the month July. This is due to intense heating in the month of June which may continue to prevail in the month of July due to late onset of monsoon or sometimes monsoon failure conditions. The heat waves events were becoming more frequent in the month of June as compared to other months from the year 2009 to 2013. In the year, 1997, 2004, 2010 and 2012, the span of heat waves more than 3 days was observed 4 times. The maximum span of heat waves of 3 days or more was observed 5 times in the year 2010. Likewise, the maximum spans of heat wave of 5 days or more was observed 4 times in the year 2010. The trends of occurrence of heat waves are presented in Figure 1. An increasing trends of heat waves were noticed in the month of May and June which might be due to continuous rising of average temperature worldwide resulted increasing frequency and duration of heat waves (Pant, 2003, IPCC, 2013). The abnormally higher temperature in reproductive stage of crop growth lead to forced maturity in rabi season crops (Satyanarayana *et al*., 2009). The other consequences of abnormally higher temperature and heat wave conditions may be seen in the form of shortening of crop duration, increase in evapotranspiration and decrease in fertilizer use efficiency etc. The change in temperature may adversely affect the growth of crops and hence agricultural products to a large extent (Attri and Rathore, 2003).

Cold waves

The data on number of days with cold wave condition along with its different spans of occurrence are presented in Table 2. Annually, 5.8 average cold wave events were observed during the period 1984-85 to 2012-13. In the last 3 decades maximum events of cold waves *i.e.* 20 were observed during 2007-08. Considerable higher cold wave events were also observed in the years 1986-87, 1990-91 and 1999-00. On an average 1.3 to 2.9 cold waves per year were analysed from December to February. The maximum span of cold waves occurring 3 days or more was observed 4 times in the year 1999-00. The trends of occurrence of cold waves are presented in the Figure 1. A decreasing trend of cold waves was observed at monthly and annual time scales. The trend analysis revealed that cold waves are becoming less frequent. This may be due to continuing rising of minimum temperature over the region resulting and reduced frequency of colder nights and cold temperature extremes (Rupa Kumar *et al*., 2002; IPCC, 2012; Kumar *et al.,* 2013; Dash and Mamgain, 2011).

Frost

The data on frost events and its trends are presented in the Table 2 and Figure 1. On an average 8.9 frost events per year were observed during the period from 1984-85 to 2012-13. January and February months were found vulnerable to frost conditions. On an average 3.0 and 3.9 frost events were observed in January and February, respectively. In the year 1986-87, maximum number of frost events was noticed *i.e.* 28. However, markedly higher frost events were observed during 1990-91, 1998-99, 1999-00, 2005-06 and 2007-08. The decreasing trends of frost events were observed in the month of January. This may be due to continuing rising of minimum temperature in winter season over the region (Rupa Kumar *et al*., 2002).

Conclusion

The impact of climatic risk on agriculture can be reduced by altering sowing period, switching to crops which are less sensitive to extreme temperatures, switching to new heat resistant varieties, dissemination of agro-advisories based on local weather forecast through mobile, encouraging adoption of weather index based crop insurance might reduce loss in the case of unfavourable weather or crop failure

Table 1: Occurrence of heat wave events at Morena (1984-2013)

Years	Heat wave frequency					Spans of heat wave		
	April	May	June	July	Annual	≥ 3 days	≥ 4 days	≥ 5days
1984	0	0	0	3	3	1	0	0
1985	0	0	13	0	13	2	2	1
1986	0	0	3	1	4	0	0	0
1987	0	0	0	0	0	0	0	0
1988	0	13	0	0	13	1	1	1
1989	0	2	0	2	4	0	0	0
1990	1	0	2	1	4	0	0	0
1991	0	0	6	10	16	3	2	1
1992	0	0	1	3	4	1	0	0
1993	1	1	4	5	11	2	1	0
1994	0	3	8	0	11	2	1	0
1995	1	4	0	21	26	2	2	2
1996	3	0	5	1	9	1	1	0
1997	3	0	5	10	18	3	2	0
1998	0	0	5	0	5	1	1	0
1999	1	4	1	0	6	1	1	0
2000	0	0	1	22	23	2	1	1
2001	0	1	0	0	1	0	0	0
2002	1	4	0	21	26	2	2	2
2003	1	0	4	0	5	1	0	0
2004	3	0	5	10	18	3	2	0
2005	0	0	5	0	5	1	1	0
2006	1	4	1	0	6	1	1	0
2007	3	0	0	0	3	0	0	0
2008	0	1	0	0	1	0	0	0
2009	2	2	10	4	18	2	1	1
2010	24	15	18	0	57	5	4	4
2011	1	5	4	1	11	0	0	0
2012	3	2	14	10	29	3	3	2
2013	0	0	11	11	22	2	2	2
Mean	1.6	2.0	4.2	4.5	12.4	1.4	1.0	0.6
CV	267.3	178.7	114.5	149.8	95.7	87.0	100.0	167.2

Table 2: Cold wave and frost events at Morena (1984-2013)

Year	Events								Spans of cold wave		
	December		January		February		Annual		≥ 3 days	≥ 4 days	≥ 5 days
	Cold wave	Frost	Cold wave	Frost	Cold wave	Frost	Cold wave	Frost			
1984-85	0	0	1	3	4	5	5	8	1	0	0
1985-86	4	5	2	3	4	5	10	13	2	2	1
1986-87	11	13	4	7	4	8	19	28	2	1	1
1987-88	0	0	7	11	0	2	7	13	1	1	1
1988-89	0	0	0	0	1	1	1	1	0	0	0
1989-90	0	0	0	0	1	1	1	1	0	0	0
1990-91	9	13	4	8	2	3	15	24	1	1	1
1991-92	0	0	0	1	1	2	1	3	0	0	0
1992-93	1	2	0	2	4	5	5	9	1	0	0
1993-94	1	4	0	1	5	6	6	11	1	0	0
1994-95	1	1	0	1	2	4	3	6	0	0	0
1995-96	0	0	1	1	1	3	2	4	0	0	0
1996-97	0	0	0	0	2	4	2	4	0	0	0
1997-98	0	0	0	1	1	3	1	4	0	0	0
1998-99	5	6	6	9	1	2	12	17	2	1	1
1999-00	0	0	3	4	13	14	16	18	4	2	0
2000-01	0	1	4	5	5	5	9	11	2	1	0
2001-02	1	2	0	1	2	4	3	7	0	0	0
2002-03	0	0	1	1	2	4	3	5	0	0	0
2003-04	0	0	0	0	4	5	4	5	1	1	0
2004-05	0	0	0	0	3	4	3	4	0	0	0
2005-06	3	6	5	7	2	3	10	16	1	1	0
2006-07	0	0	0	3	1	1	1	4	0	0	0
2007-08	2	3	5	8	13	15	20	26	3	2	1
2008-09	0	0	0	2	1	1	1	3	0	0	0
2009-10	0	0	3	5	2	2	5	7	0	0	0
2010-11	0	0	1	4	1	1	2	5	0	0	0
2011-12	0	0	0	0	0	0	0	0	0	0	0
2012-13	0	0	0	0	1	1	1	1	0	0	0
Mean	1.3	1.9	1.6	3.0	2.9	3.9	5.8	8.9	0.8	0.4	0.2
CV	209.1	186.2	134.4	105.1	110.0	88.1	99.2	86.1	139.4	153.0	199.3

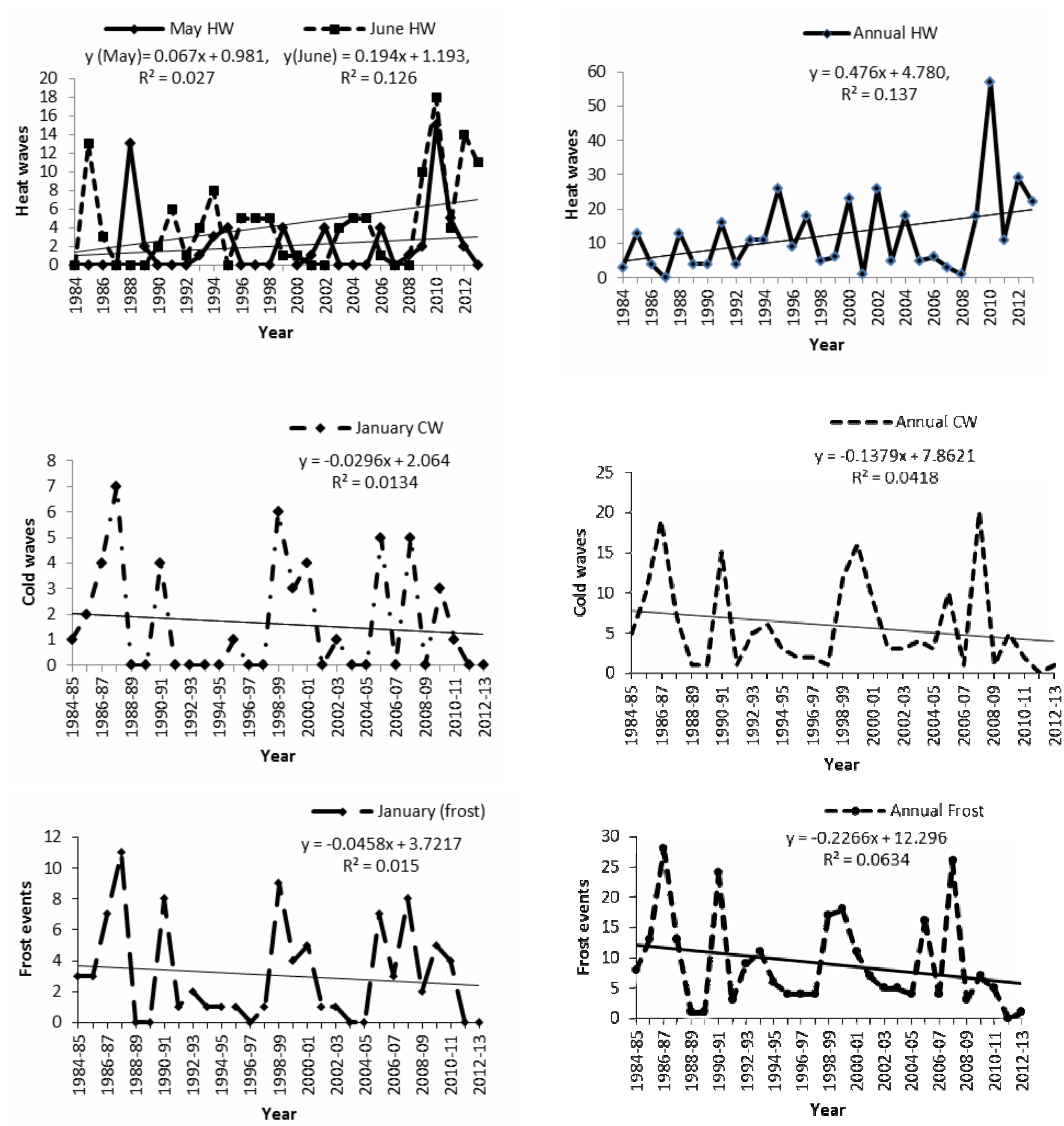

Fig1: Trends of extreme weather events at Morena (1984-2013)

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