

Impact of Extreme Weather Events in Relation to Heat and Cold Waves over India in Recent Years

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ABSTRACT

Fatalities reported during the last decade due to extreme weather events compiled by World Meteorological Organisation (WMO) showed India as one of the five worst affected countries in the world. As per WMO, each of the past several decades has been significantly warmer than the previous one. The period 2011-2015 was the hottest on record, and the year 2015 with an extra boost from powerful El-Nino was the hottest since 1800s. There have been several events of heat waves across the globe. The extreme temperature events such as heat waves and cold waves can cause enormous losses of standing crops, live stock and fisheries. These events are also associated with various health impacts on human beings such as heat stroke and ailments of lungs etc. In view of the above, to find the impact of heat and cold waves over India, incidences of natural hazards reports and annual climate summary prepared by India Meteorological Department for the period 1981-2015 have been used in the study. Casualties due to heat and cold waves over India have also been discussed. Only those cases have been included in this study, which caused human fatalities and significant economic losses. Statistical techniques have also been used to find the trend in casualty of heat and cold waves over India. It is observed that heat wave/cold waves have caused significant social impact and economic losses. Heat wave of 2016 caused over 500 deaths from central and peninsular part of the country during April and May. Of these, over 300 deaths were reported from Telangana alone. Some places in West Rajasthan viz. Phalodi & Churu recorded high temperatures of 51° C and 50° C respectively on 19th May. February 2017 has been found as the warmest February in the past 100 years.

Keywords: *Extreme weather events, Natural hazards, Anthropogenic changes, Climate changes and Heat & cold waves.*

1. Introduction

The important finding in the WMO annual statements on the status of the Global Climate is that the period 2011-2015 is the world's warmest five year period on record. Global temperatures over the 2011-2015 period have been 0.57°C above the average with respect to 1967-1990 reference period and 0.06°C warmer than the previous record holder period 2006-2010. The last five years have also included the two warmest years on record. However 2015 was by far the warmest year.

We cannot avoid natural hazards (like heat wave/cold wave, flood etc.) and disasters, but can minimize their impact on environment by preparedness & planning. In recent years rapid anthropogenic climate change is mainly forced due to enhanced emission of greenhouse gases (GHGs) and aerosols linked with industrial development which started nearly 200 years back. Studies during the twentieth century showed that an anthropogenic

climate change has raised the average global temperature from 1860 till date at different rates.

RupaKumar (1994), De and Mukhopadhyay (1998)) have studied the temperature data for the Indian region. Studies on the impacts of global warming showed that impacts can be reduced only by controlling emission and by adaptation measures linked with sustainable development path ways advocated in United Nation Convention on Environment of Development (UNCED) or Rio 1995. Jones & Bifra (1998) found that in the last century, the last decade 1991-2000 was the warmest in the last 140 years. Surface air temperature during the pre-monsoon season also influences soil moisture and hence the performance of the ensuing monsoon (Krishnakumar et al., 1998). Many studies have analysed different temperature variability patterns over India. Kothawale and Rupa Kumar (2005) indicates that mean maximum temperature increased over India during 1901-1987 and there is a significant warming trend in annual mean temperature over India which appears to be mostly

due to increasing T_{max} during the period 1901-2003. The extreme temperatures like heat wave can also cause enormous losses of standing crops, livestock and fisheries. Similarly, the other temperature extreme like the cold wave during winter associated with frost conditions is also very sensitive to winter crops (De et al., 2005; Dash and Mamgain, 2011). Associated with high T_{max} in summer, most areas in India experience episodes of heat waves causing sunstroke, dehydration and death (De et al., 2005; Pattanaik & Mukhopadhyay, 2012).

The Internal Displacement Monitoring Centre (IDMC) has estimated that between 2008 and 2014, an annual average of at least 22.5 million people were displaced by the direct threat or impacts of floods, landslides, storms, wildfires and extreme temperatures on their safety, homes and livelihoods (WMO, 2016).

The surface air temperature drives crop growth, duration; influences milk production in animals and spawning in fish. Temperature in conjunction with relative humidity can influence pest and diseases incidence on crops, livestock and poultry. Thus, for agro economic country like India the variability of surface air temperature on different temporal scales also very crucial for policymaking and the national economy (Rathore et al., 2016). The current trends of climate change are expected to increase the frequency and intensity of existing hazards, an increased probability of extreme events, and vulnerabilities with differential spatial and socioeconomic impacts

2. Data and Methodology

Incidences of natural hazards reported in Disaster Weather events prepared by India Meteorological Department (IMD) for the period 1981-2015 have been used in this study. A yearly data series of number of deaths and impact of heat waves was prepared. Statistical techniques have also been used to find the trend in causality of heat waves and cold waves over India. Only those cases have been included in this study which can cause human fatalities and significant economic losses.

3. Discussion

As per the study of Larson (2003), the frequency of extreme weather events as well its intensity have increased. He also found that the high impact of summer of 2003 killed more than 30,000 persons in Europe.

The Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report (AR4; IPCC, 2007) has also projected more frequent and intense weather events in the twenty-first century with high confidence levels. This is likely to further degrade the resilience and coping capacities of poor and vulnerable communities. Thus, the extreme events (e.g., high rainfall/floods, heat wave/cold wave, cyclone, hail/frost etc.) cause enormous losses of standing crops, livestock and fisheries. Thus, it is very desirable to study the observed spatial and temporal variability of weather and climate extremes such as high/low rainfall, floods/droughts, heat/cold wave, cyclone, hail/frost etc. Yet efforts are needed to meet future needs of the planet by moving on a sustainable path which appears to be an answer to global warming.

Global data show various signatures of climate change. Some signatures (Rosser, 2008) are listed below:

- a) There has been almost continuous rise in average global temperature from the base line value of 1860. The rate of increase in temperature is getting steeper in recent decades after 1980's. In 1995, this rate was between 0.38 & 0.6°C since last century. The updated trend during period 1906-2005 is 0.74°C for the last hundred years.
- b) Increases in the intensity and frequency of extreme weather events such as tropical cyclones, heavy rainfall, floods, droughts, heat and cold waves at global, regional and local levels have been recorded.
- c) Concentrations of all major Greenhouse Gases have increased since 1860. The concentration of CO₂ has risen by almost 100 ppm (260-379 ppm) since 1860. It is now almost certain these recent aspects of global warming is very likely to be associated with anthropogenic causes of rising

GHG concentration (IPCC 2012), which is 1.95 ppm/year during 1995-2005.

The data published by the Global Climate Summary of WMO shows that the last three decades (1981-2010) were warmer than the preceding 14000 years. On the other hand, some of the years with record high global mean temperature include 1998, 2005, 2009 and 2016. On the regional and sub-regional scale, Australia had its warmest year in 2013. Similarly, the summer of 2013 was perhaps warmest in Europe (WMO, 2016). Over the Indian sub-continent, the year 2015 was warmer by 0.67°C above the long term mean temperature making it third warmest year since 1901. India recorded abnormally high annual mean temperatures during 2009, 2010, 2015, 2003, 2002, and 2014. The warmest 12 years have occurred during the period (2001-2015) over the country (IMD, 2016). During recent years (2011-2015) the rise of temperature was at a steeper rate being 0.74°C above the level of 1961-90 (WMO, 2016). The impact of these extreme weather events were generally felt unevenly being most severe in South and South-East Asia and Latin America.

Among the South Asian countries, India has been ravaged by catastrophic extreme events of epic proportions and the increasing frequency of natural disasters has been a blow to lives of the people. It is among the most disaster-prone countries in the world owing to its climatic and physiographic conditions (NDMA, 2016). Heat waves, droughts, floods and cyclones are among the main extreme weather events or natural disasters that cause damage to livelihoods in Odisha (SANGRAM et al.2019).

As per National Disaster Management Authority (NDMA-2019), heat wave caused 24223 deaths from 1992-2015 across the country. Over the past several years India has witnessed the increasing trend in heat waves that severely affected several states. In 2015, nine states were affected by heat waves and 13 states recorded temperature beyond threshold temperature in 2016.

Heat wave of 2016 caused over 500 deaths from central and peninsular part of the country during

April and May (IMD, 2017). Of these, over 300 deaths were reported from Telangana alone.

4. Results

When the data over the whole period of 1981-2015 are analyzed for cold waves and the number of annual deaths were examined, no trend has been observed as depicted in Figure 1. It also noticed that maximum deaths of 1158 occurred in the year 2003 followed by the year 2011 (722). On the other hand, in case of heat waves, there is significant increasing trend in Figure 2. It is noticed that maximum deaths of 2099 occurred in 2015 as against 1712 in 1998. When decadal analysis for cold waves is conducted, it is observed from Figure 3 that number of deaths for the period 2001-2010 was the highest at 2688 followed by 2344 in the decade 1981-1990. During the period 1991-2000, it was the lowest (1227). It is worth noting that there is increasing trend in the number of deaths due to cold waves although it is not statistically significant.

Similar analysis was done for heat waves. It is observed that, for the period 2001 to 2010, number of deaths was the highest (3558) followed by the decade 1991-2000 when 2774 deaths occurred. The lowest number of deaths was observed during the period 1981-1990 at 1402. From Figure 4, it may also be observed that, the trend in number of deaths due to heat waves has been increasing and it is statistically significant. Even in the period of 2011-2015 both the cold and heat waves show increasing trends.

Table 1 gives the list of Extreme Weather Events i.e. heat and cold waves in India and their impact over different parts of country during 1981 to 2015. It is to be noted that casualties due to heat waves are more as compared to cold waves.

From the above discussion, it is inferred that the impact of heat and cold waves have increased during recent years causing significant social impact over India. This results are in agreement with Global Climate Summary of WMO (2016) and NDMA Report 2019.

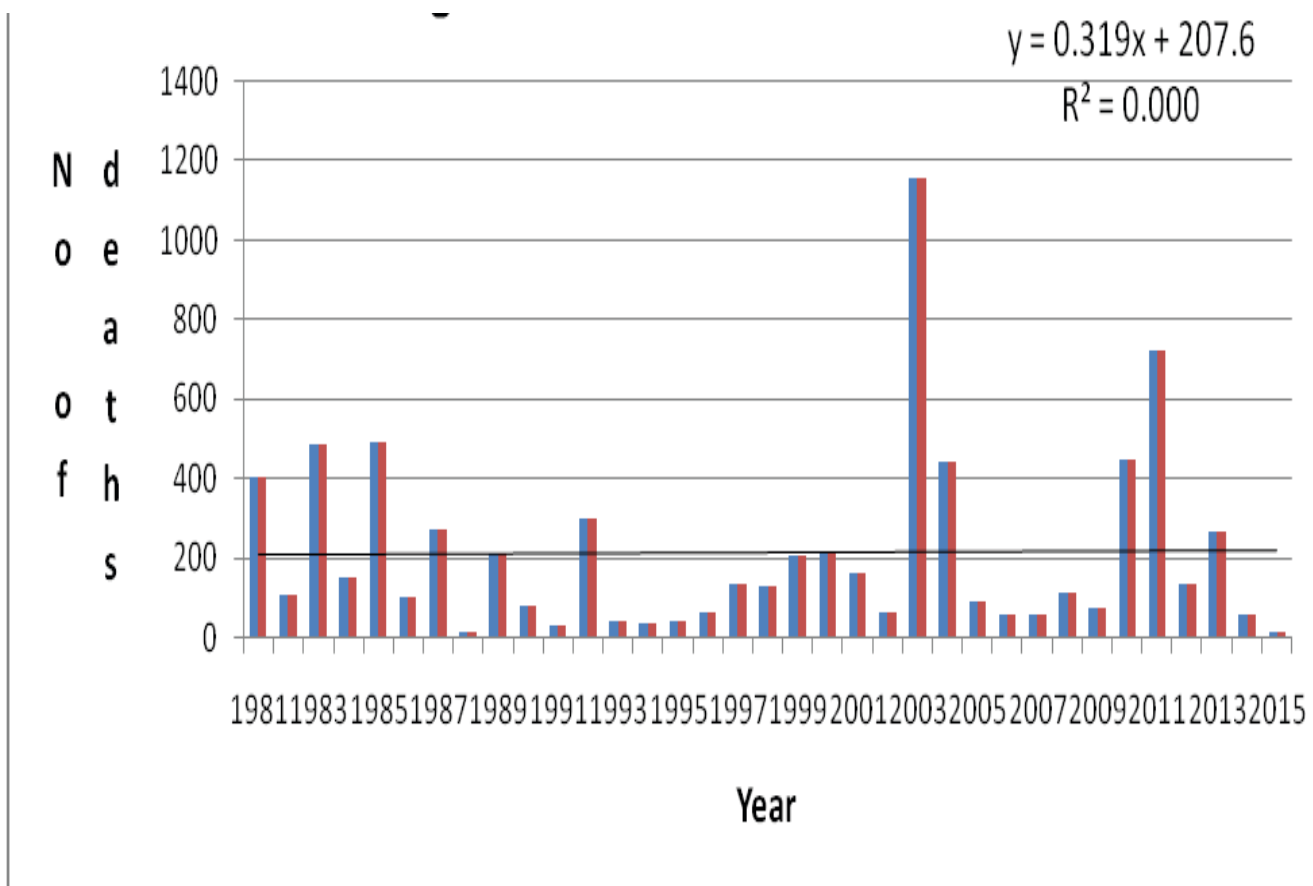


Figure 1: Year wise deaths due to Cold Wave.

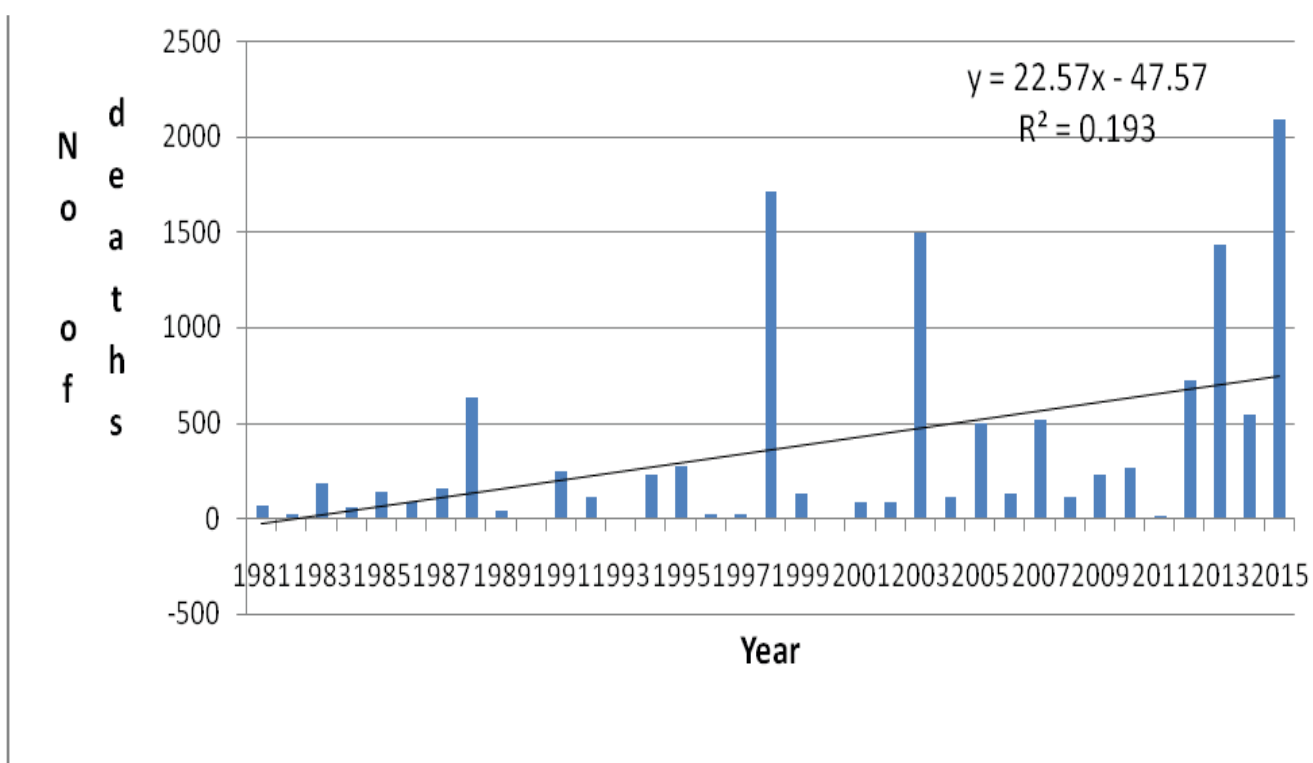


Figure 2: Year wise deaths due to Heat Wave.

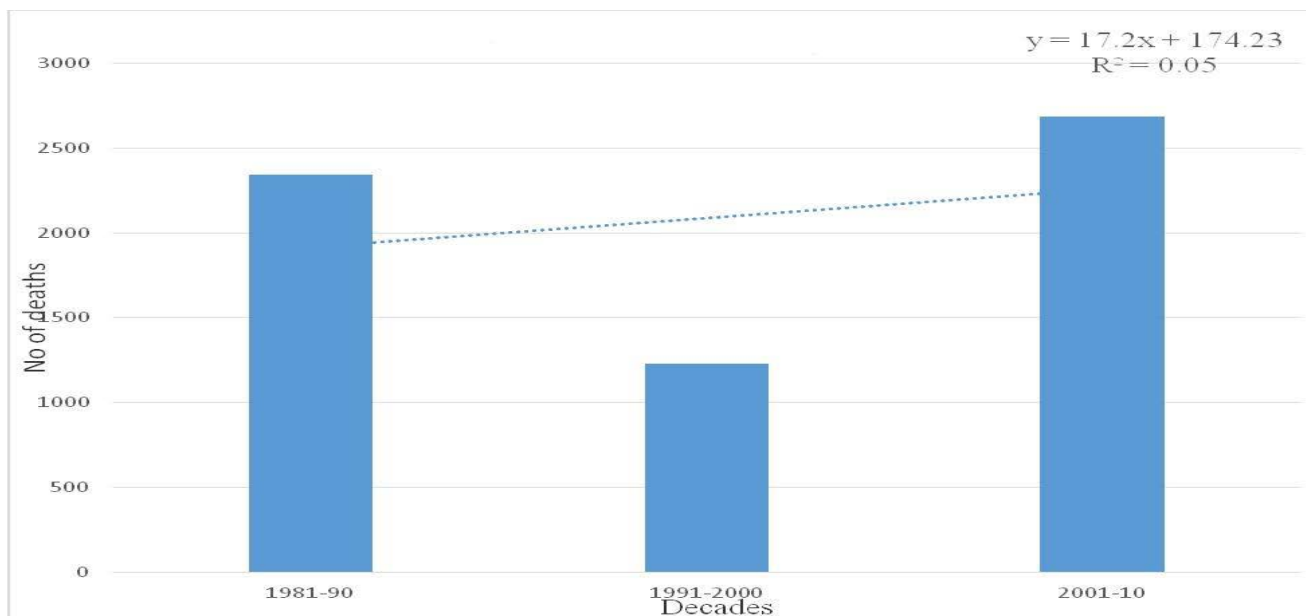


Figure 3: Decades wise deaths due to Cold Wave.

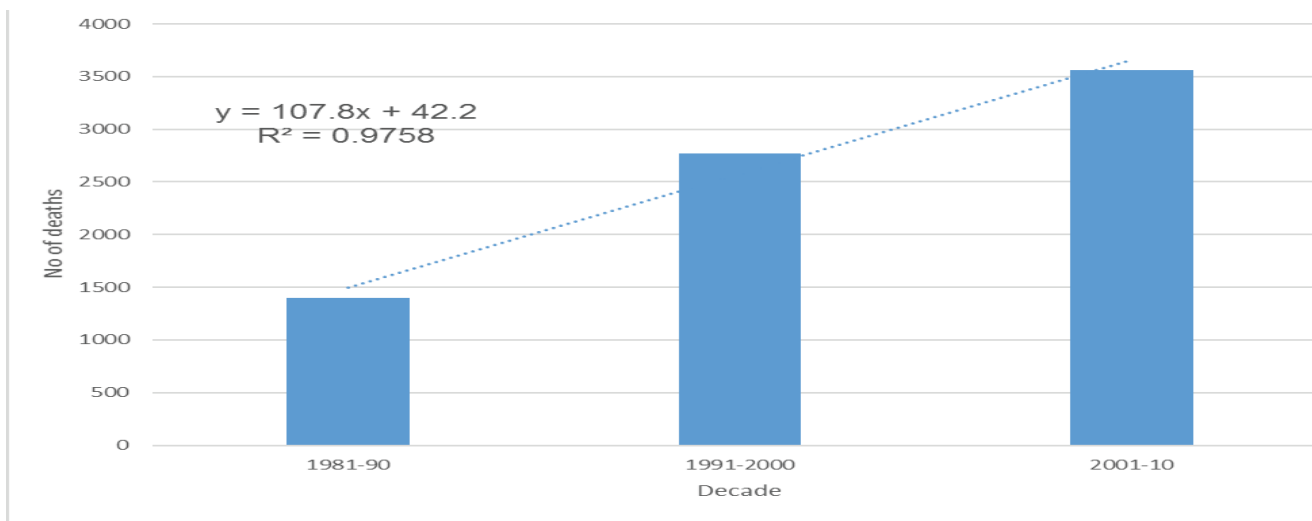


Figure 4: Decades wise death due to Heat Wave.

5. Conclusions

Following conclusions could be drawn from this study:

- i) Number of deaths due to heat waves during the study period 1981-2015 has been increasing significantly whereas due to cold waves it is increasing but not with any statistical significance.
- ii) Decadal study of deaths due to cold waves during the study period shows that the number of

deaths for the period 2001-2010 was the highest followed by that in the decade 1981-1990. Decadal analysis also shows increasing trend in the number of deaths due to cold waves although it is not statistically significant.

iii) Decadal study of deaths due to heat waves yields that, in all the decades there were increasing trends with statistical significance.

iv) The impact of heat and cold waves have increased during recent years that has caused

Table 1: Extreme Weather Events in India and its impact

S.N.	Year	Weather Events/ Area	Numbers of deaths reported
1	1981	Cold wave conditions prevailed over northern part of the country	408
2	1983	Cold wave conditions prevailed over Punjab, M.P., Bihar, Odisha, Maharashtra, Andhra Pradesh	486
3	1985	Cold wave conditions prevailed over northern part of the country	494
4	1988	Heat wave conditions prevailed over Northeastern, Central parts of India	635
5	1998	Severe heat wave conditions prevailed over Andhra Pradesh, M.P.	1712
6	2000	Cold wave conditions prevailed over northern part of the country	514
7	2002	Severe heat wave in Andhra Pradesh, Rajasthan, West Bengal and Orissa.	800 (600 deaths in Andhra Pradesh alone)
8	2003	i) Severe cold wave over most parts of north India during January. ii) Heat wave over Andhra Pradesh during 2 nd fortnight of May and 1 st fortnight of June.	i) 1300 ii) 1496
9	2005	Heat wave swept across northern parts of the country and Maharashtra state in different periods during April, May and June months.	588
10	2012	Heat wave conditions prevailed over some parts of the country	729 (366 from Andhra Pradesh, 142 from West Bengal and 104 from Jharkhand)
11	2013	Heat wave conditions prevailed over Northeastern, Central and Peninsular parts of the country.	Over 1400 (1393 from Andhra Pradesh alone)
12.	2014	Heat wave conditions prevailed over Andhra Pradesh, Telangana, Odisha, Rajasthan, west Bengal, Maharashtra	547
13	2015	Heat wave conditions prevailed over Northeastern, Central and Peninsular parts of the country.	Over 2000 (1422 from Andhra Pradesh and 584 from Telangana)

significant social impact over India. It is also found that casualties due to heat waves are more as compared to those due to cold waves.

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