Extreme Weather Events in India- A Preliminary Analysis of Impacts

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Abstract

Extreme weather events have enormous impacts to human society and environment. India is highly vulnerable to climatic extremes due to high population density, poor infrastructure, low human development and minimal coping capacity. In this context, it is important to look at damage caused by climate extremes over India spatially and temporally. Impact data constitute information about mortality, persons affected, villages affected, crops affected and total economic loss. All events combined show a significant increasing trend in impact. Impacts from dust storms, floods, hail storms and lightening show increasing trend. Floods share highest impacts caused by climate extremes. Total mortality due to the extreme events is greatest in Odisha. Normalised mortality is mortality per unit population. Odisha state has highest normalised mortality. Cold waves have a significant increasing trend in impact on Haryana, Rajasthan and West Bengal, whereas significant decreasing trend in Madhya Pradesh. In all states it is observed that there is increasing trend in heat wave occurrences. Finally policy implications of impacts of these events and future work have been discussed.

Key words : Extreme weather events, climatic extremes, heat wave, cold wave.

Introduction

Climate change may be perceived mostly through the impacts of extreme weather events, although these are to a large degree dependent on the system under consideration, including its vulnerability, resiliency and capacity for adaptation and mitigation. Growing human vulnerability due to increasing numbers of people living in exposed and marginal areas or due to the development of more high-value property in high-risk zones, is increasing the risk, while human endeavours, such as, by local governments, try to mitigate possible effects. As climate continues to warm during the course of the 21st century, it is expected that many forms of extreme events may also increase, because the thermal energy that drives many of these processes

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will be enhanced. Public awareness to extreme weather hazards has risen sharply in recent years, in part because of the instant media attention that serves to emphasize the catastrophic nature of floods, droughts, storms and heat waves. Additionally, the economic costs of extreme events have increased in the past few decades, essentially because there has been a substantial rise in the number of inhabitants and penetration of infrastructure in risk-prone areas (e.g., Munich Re, 2005; Swiss Re, 2005). Insurance statistics highlight the fact that, with the exception of earthquakes, extreme climate events are those that take the heaviest toll on human life and exert some of the highest damage costs related to natural hazards. In the second half of the 20th century, there were 71 "billion-dollar events" resulting from earthquakes, but more than 170 events related to climatic extremes, in particular storms (tropical cyclones and mid-latitude winter storms), floods, droughts and heat-waves (Swiss Re, 2003). 2005 alone experienced one of the busiest hurricane seasons on record, with hurricane Katrina devastating the city of New Orleans with damages costs approaching an estimated USD 200 billion. The damage due to Odisha super cyclone of 1999 was estimated around Rs 100 billion (http://ncrmp.gov.in/ncrmp/Cyclone_Impact.html)

There is thus an obvious interest and incentive for the research community as well as the public and private sectors to focus on impact of extreme climatic events and the possible shifts in their frequency and magnitude. The shifts in extremes in a changing climate requires an understanding of the physical mechanisms that underlie these events. This in turn allows improvements in our ability to quantify the costs associated with climate-related hazards. Strategies for adapting to changes in mean and extreme climates can then be developed if there is a greater confidence in the understanding of these mechanisms. To develop future adaptation strategy it is important to understand historical impacts and their adaptation strategy to climate extremes. In Indian scenarios information on extreme climate events are scattered and very few attempts have been carried out (De et al., 2005a). A significant mortality caused by heat and cold waves in few northern states and Odisha is reported in a few studies (Chaudhury et al. 2000; De et al. 2005b). Significant rising trends in the frequency and the magnitude of extreme rain events in central India have been reported in a study (Goswami et al., 2006) using recent gridded dataset. The lack of information leads to present study of the spatio-temporal pattern of impact of climate extremes in India.

Data and Methodology

Data on the occurrence of extreme climate events and their impacts have been extracted from the reports on 'Disastrous Weather Events', an annual publication of India Meteorological Department (IMD). These reports are available from 1967 to 2006 (missing year 1977). They provide the information about characteristics and damage estimates of ten categories of events: flood, tropical cyclone, heat wave, cold wave also gale, squall, lightning, dust-storm, hailstorm and thunderstorm. They also provide information about the extreme event's characteristics including intensity, magnitude, location and date of occurrence and data on damage caused by these events. Damage data include information about mortality, persons affected, village affected, crops affected and total economic loss. There is considerable variation with regard to the reporting of damage information. Therefore we have only included information pertaining to mortality, persons affected, villages affected, crop area affected and total economic loss which are reported consistently for a large number of the events. Data source for the characteristics of the events are the meteorological stations installed by IMD. While there are in general many possible sources of information on extreme events, the IMD reports are perhaps the most extensive and consistent source. The impact data have been grouped into spatial resolution at state level. These data having state level information have been analyzed for trend and other descriptive statistics.

Results and Discussion

The years from 1967 to 1976 seems to have a reporting bias as the presentation of the report is organised in textual form. The data from 1967 to 1976 are ignored. The data from 1978 onward is in tabular form and more consistent in reporting hence considered in the present study. There is a highly significant increasing in the total number of events. A significant increasing linear trend in occurrence of extreme weather events has been observed. Figure 1 shows this trend with an increment of about 9 events per year on a linear scale.

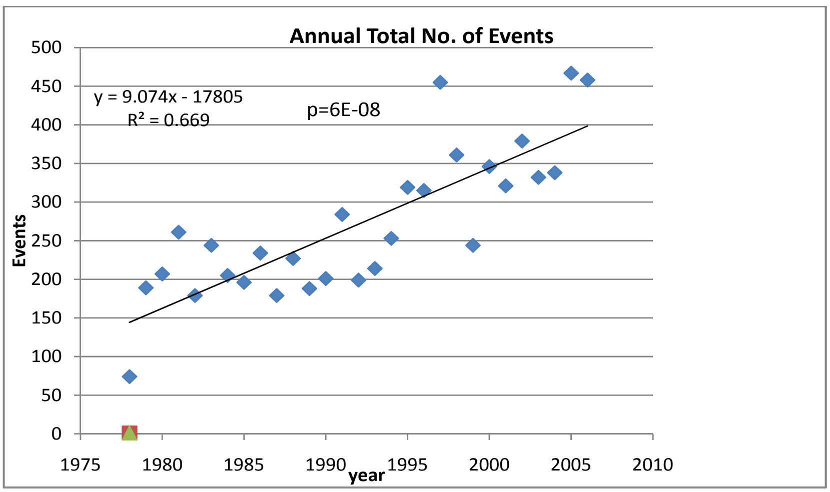

Figure 1: Annual total number of extreme climate events in India

Annual total mortality per year has increased from 1699 in 1978 to 3178 in 2006 (Figure 2). The mortality shows a considerable fluctuation across the years. It has more when the extremely disastrous cyclonic events have occurred, thus causing a large variance. The total mortality has significant increasing trend (even if ignoring the high value of 1999). Overall an increase of mortality due to extreme weather events (70 persons per annum) is revealed statistically significant.

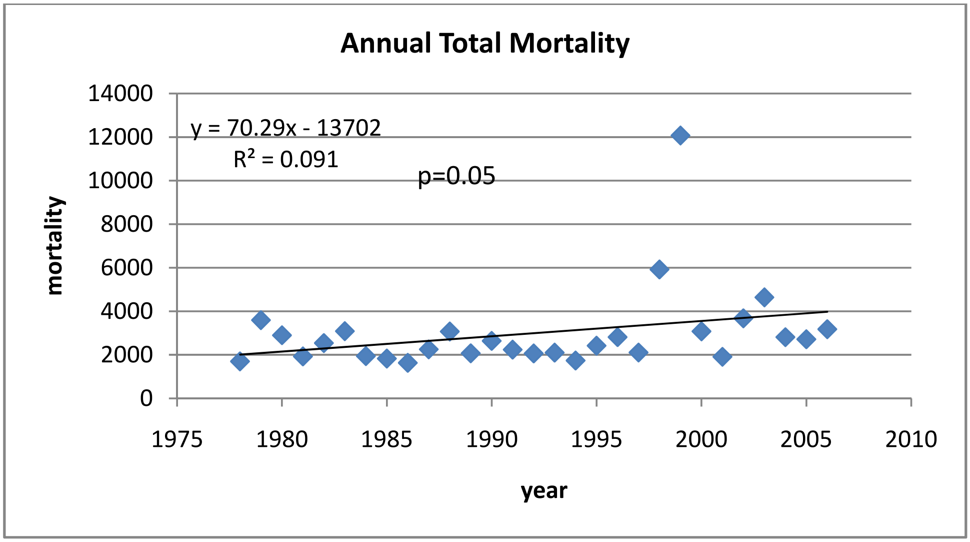

Figure 2: Annual total mortality in India due to climate extremes

Table 1: Trend in Extreme Climate Events by Impact

	Impact	
Event	**Trend (person/y)**	**p-value**
Cold wave	5.55	0.06
Cyclone	-7.58	0.81
Dust storm	0.92	0.03
flood	40.25	0.00
Gale	0.09	0.72
Hail storm	1.27	0.00
Heat wave	7.77	0.16
Lightening	7.36	0.00
Squall	0.23	0.12
Thunder Storm	5.07	0.00

Mortality due to various extreme events, as an indicator of impact has mixed trend (Table 1). Impacts due to cyclone has insignificant decreasing trend while that of other extremes have increasing trends. Flood, duststorm, hailstorm, lightning and thunderstorm have significant increasing trend in their impacts. On impact sharing, major chunk is due to flood (44%) (Figure 3). Impacts due to cyclones stand on second number, having share of 30% of all. Thus almost 75% of mortality due to extreme events is because of flood and cyclone. Impacts due to heat and cold waves share 18% of total. Rest of the impact is due to lightning, thunderstorm, duststorm, hailstorm, gale and squall.

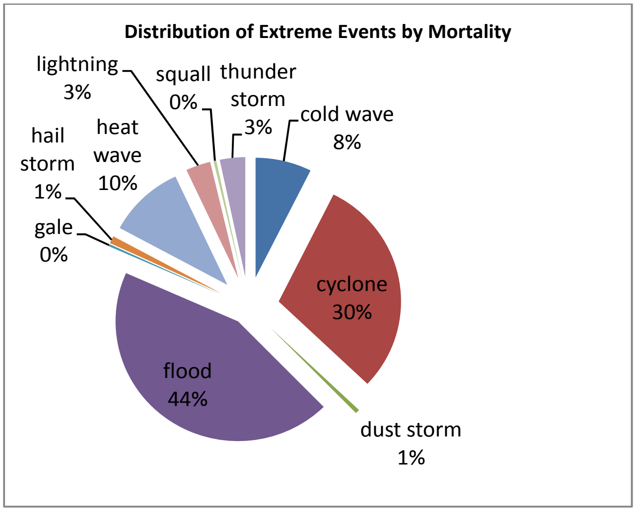

Figure 3: Distribution of the extreme events by mortality

Table 2: Leading states in the extreme events by number and mortality

Extreme Event	Leading States	
	No. of Event	**Mortality**
cold wave	Bihar	Bihar
cyclone	Andhra Pradesh	Odisha
dust storm	Uttar Pradesh	Uttar Pradesh
flood	Maharashtra	Uttar Pradesh
gale	Kerala	Odisha
hail storm	Maharashtra	Bihar
heat wave	Rajasthan	Andhra Pradesh
lightning	Maharashtra	Maharashtra
squall	Assam	West Bengal
thunder storm	West Bengal	West Bengal
Total events	Maharashtra	Odisha

The spatial distribution of events by associating each event with one (or more) states have been examined. 0. Most affected states in the extreme events by their impacts are calculated and presented in table 2. Although Odisha does not lead in the occurrence of any extreme weather events, but the total mortality due to the extreme events is highest in Odisha (Figure 4). Also mortality due to cyclone and gale is highest in Odisha (Table 2). Odisha stand first in normalised mortality also (Figure 5). Mortality due to coldwave is in its peak in Bihar. Bihar also leads in mortality due to hailstorm. Mortality due to flood and dustsorm is maximum in UP. Heatwave mortality is highest in Andhra Pradesh. This reveals the importance of considering exposure and coping capacity due to weather extreme events while assessing vulnerability.

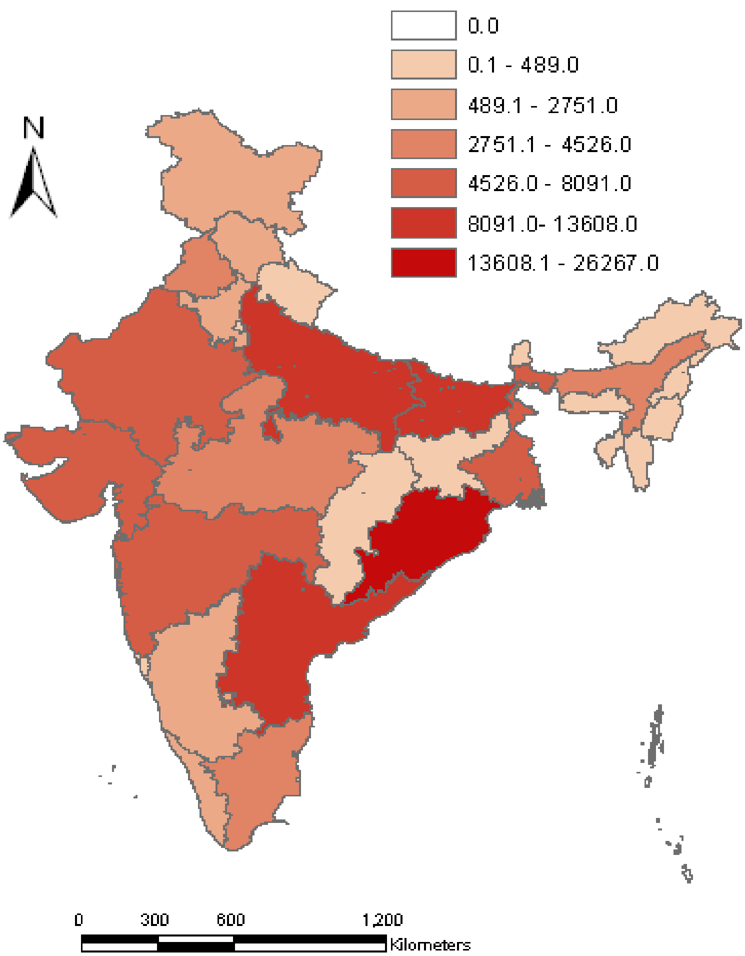

Figure 4: State wise total mortality due to climate extremes

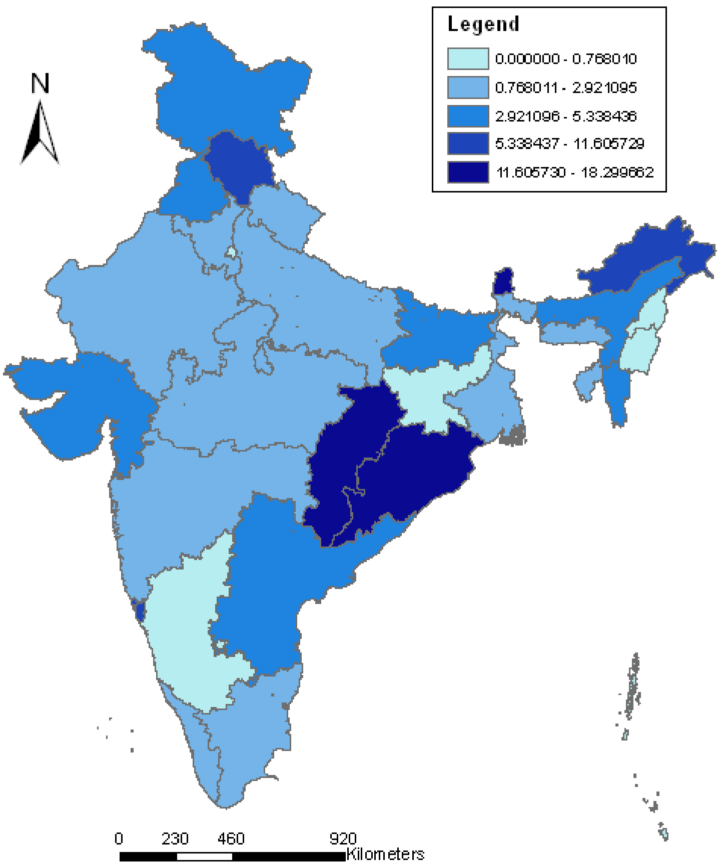

Figure 5: State wise normalised mortality per millio due to climate extremes

Conclusion

India is a large developing country with a population of over one billion, whose growth is projected to continue in the coming decades. In India, nearly two thirds of the population is rural, whose dependence on climate-sensitive natural resources is very high. Its rural population depends largely on the agriculture sector, followed by forests and fisheries for their livelihood. Indian agriculture is monsoon dependent, with over 60 per cent of the crop area under rainfed agriculture that is highly vulnerable to climate variability and change. Developing countries such as India have low adaptive capacity to withstand the adverse impacts of climate change. India has to be seriously concerned with the possible impacts of climate change. The assessment of climate change impacts and adaptation to climate change require a wide range of physical, biological and socioeconomic models, methods, tools and data. The methods for assessing the vulnerability, impact and adaptation are gradually improving, but are still inadequate to help policy-makers formulate appropriate adaptation measures. This is due to uncertainties in regional climate projections, unpredictable response of natural and socio-economic systems and the inability to foresee future technological developments coupled with inadequate data, poor infrastructure and weak implementation strategy.

Policy-makers must formulate plans to turn disasters into opportunities. There are lessons to be learned from how wealthier nations respond to crises following man-made disasters, such as the financial slump and technological adversities. In many such cases, policies are enacted to address the underlying problems that brought on catastrophe (such as poor regulation of the financial system), rather than simply focusing on the proximal cause (such as sub-prime mortgages) and attempting to bring conditions back to 'normal'. The fundamental problems exposed by these disasters are often known and highly predictable. However, the focus must be for changing underlying conditions for the better, rather than on a superficial rebuilding of what existed before. The underlying problems of poverty, poor construction, ineffective administration, inefficient enforcements of rules and regulations, and lack of economic security need to be addressed more comprehensively.

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