

Climate Change and Health and Heat Wave Mortality in India

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Abstract

The paper highlights the growing concern of the impact of climate change and variability including rainfall anomaly, rising temperature in mountain areas and occurrence of heat waves in relation to human mortality pattern in India. The paper investigates the historical perspective of rainfall and malaria relationship, and cited current studies to show how climate change and variability resulted in large scale human loss in India. Based on data on rainfall pattern in the desert part of Rajasthan, the paper argued that the rainfall pattern is changing. However, the summer monsoonal rainfall of 500 mm and above may be taken as an indicator in forecasting malaria outbreak in the Thar Desert. The paper also argued that global warming has resulted in increased heat wave conditions in India and accordingly resulting in increased deaths due to heat wave conditions in different parts of India, particularly in the northwestern, south, and southeastern regions.

Key words: climate change, flooding, heat waves mortality, malaria, rainfall anomaly

1. Introduction

Global climate change generally have both positive and negative impacts on human health. Rainfall anomaly and heat wave condition play an important role in causing ill health in various ways. Though on a global scale changes in precipitation and temperature patterns are now well established. In India too, there is realization that climate change is a phenomenon that cannot be ignored. Rainfall variability in relation to the outbreaks of malaria had been documented in a number of studies. Similarly, the rise in heat wave mortality in India over space and in time indicate the changing environmental condition in India. Global warming could lead to severe droughts affecting agriculture and to leave forests and coastal areas vulnerable. The projected climate change scenarios indicate increase and variable trend of both rainfall and temperature into the 21st century. The initial analysis has revealed that climate change may have adverse effects in terms of severity of droughts and intensity of floods in various parts of the India.

2. Rainfall and Malaria: 19th Century Observations

Based on 1869 data, Macnamara (1880) provided an account on climatic conditions and malaria out-

breaks in northern and western India. It is surprising to note that Christopher and Sinton (1926) who prepared a malaria map of India (Christopher, 1911) have not mentioned this pioneering attempt by Macnamara. Macnamara noted, at several stations, in the upper Gangetic plains and in the Punjab as well as in Bengal, the rise in the number of admissions for fever is very marked during July and August, the most equably months in respect to temperature of the year and the admissions attain their maximum frequency in September. He further observed that probably, throughout Bengal, much of the northwest provinces, and parts of the Punjab, the average rainfall quite suffices to foster as abundant.

Table 1 shows monthly mortality figures due to malaria as reported in northern and western India. It is indicated that mortality rises with increase in rainfall, with maximum in October and declines from November onwards. Macnamara (1880) quoted Surgeon J.R. Johnson, who stated that it was in fact pure malarious fever, and probably caused, or at any rate greatly

Table 1 Fever deaths in Northern and Western India. (Macnamara, 1880)

1869	July	August	September	October	November
Number of deaths	13,734	15,595	31,307	44,221	36,332

aggravated by late and heavy rains. A most decided increases in the number and severity of the attacks was observed about/on September 20, and from that date to the end of October the disease was at its work.

Thus Hehir (1927) has rightly postulated that, in general terms it may be stated that malarial fevers are most prevalent in India during the years of the heaviest monsoon rains, there are the years in which we get outbursts of high endemicity and this is particularly the case in the level plains, and localities in which the drainage is slow or in any way obstructed. In the context of Thar Desert, poor drainage obstruct flood.

3. Environment and Health in India – Malaria, Cholera and Other Diseases

Although not many studies concerning environment and health dimension were conducted, still a number of investigations focused on various environmental factors in relation to disease occurrence in India with a major thrust on malaria (Gill, 1923, 1931, 1933).

A significant study was undertaken by Learmonth (1957) who studied the regional geography of malaria in Indian-subcontinent, with an identification of endemic and epidemic zones of malaria.

Banerjee and Hazra (1974) examined geocological factors in relation to cholera in West Bengal. Akhtar and Learmonth (1977) focused on the resurgence pattern of malaria in India during 1965-1976, and studied the diffusion pattern from the environmentally different four foci regions. Temperature and rainfall were studied in relation to the occurrence of diseases in India by Akhtar (1979) with particular reference to malaria and waterborne diseases.

Hyma and Ramesh (1980) highlighted the reappearance of malaria in Sathanur reservoir and environs: Tamil Nadu India, and Dutt, *et al.* (1980) concerned with the incidence of malaria in two west central states of Gujarat and Madhya Pradesh. Akhtar (1980) in his book "*Environment, agriculture and nutrition in Kumaon region*" examined the interrelationship between environmental factors and level of agricultural production and availability of nutrition in a mountain region of Kumaon.

Ramachandran (1984) presented the findings on the relationship between some environmental elements and incidence of influenza, fever, dysentery, asthma, tuberculosis and typhoid in rural areas of Tumkur district, Karnataka. Akhtar and Learmonth (1985) edited a book "*Geographical aspects of health and disease in India*," which comprises case studies on environmental set up of malaria, goitre, smallpox and guinea worm disease. Choubey (1985) studied the incidence of diseases in Sagar city in central India as a consequence of environmental and nutritional factors.

Bouma (1995) and Bouma *et al.* (1995) reported the epidemic malaria in northern Pakistan and in Thar Desert, respectively. Sharma (1955) noted malaria

menace.

Mathur (1991) examined the higher concentration of fluorides in the soils of eastern part of Indian desert zone with implications of fluorosis, and Akhtar and McMichael (1996) assert that both the heavy rainfall and the number of rainy days were associated positively in the outbreaks of malaria in desert region of Rajasthan in 1994. Mathur and Panghaal (1998) conducted their study on the geographical correlates of tuberculosis in Haryana state.

Akhtar (2004) traced the historical perspective of environmental scenario and diseases in Kashmir during late 19th century. In a joint study, Dutt *et al.* (2006) reexamined the outbreak of plague in Surat city in 1994 in the background of flooding, insanitary conditions, and environmental deterioration.

In a recent study on the impact of climate variability on vector borne diseases, Dhiman (2007) asserts that meteorological parameters, changes in ecological conditions, development of resistance in *Plasmodium falciparum* parasite and lack of surveillance are the likely reasons. Dhiman opined that the outbreaks of dengue and chikungunya are also associated with climate variability.

4. Changing Rainfall, Floods, Irrigation Canals

4.1 Rainfall changing pattern in the Thar Desserts

It is worthwhile at this stage to study the changing rainfall pattern in the desert region. Goudie (1983), who studied the changing rainfall pattern in arid areas, including the Thar Desert, noted changes in rainfall 1890 to 1895. Conditions had been relatively wet in the 1880s and 1890s. In these periods, June - September summer monsoon rainfall was 2,422 mm, but 2,472 mm in 1891-1900. There followed a period of low precipitation: that is precipitation in the driest decadal period was generally only between 52% and 69% of that for the wettest decade of this century. The decreases in the summer rainfall was also noted during 1957-1970. The analysis of data for Bikaner and Jodhpur of Thar Desert showed that summer monsoon rainfall decreased steadily by more than 45% since 1957 as shown in Table 2.

Analysis of data of flood years in the desert region during the period of 123 years since 1871 showed that only five years (flood years) recorded summer monsoon rainfall above 500 mm (Parthasarathy, 1987). These years were 1908 (573 mm), 1917 (564 mm), 1944

Table 2 Five year running mean percentage of normal summer monsoonal seasonal rainfall centred on 1957 and 1970.
(Source: A. Goudie (1983))

	1957	1970
Bikaner	114	71
Jodhpur	115	68

(542 mm), 1990 (777 mm) and 1994 (544 mm), 1994 being the year of the last malaria outbreak in the region. Similarly malaria was also reported in epidemic form during 1990 flood year. The summer monsoonal rainfall of 500 mm and above may be taken as an indicator in forecasting malaria outbreak in the Thar Desert.

4.2 Irrigation canals

The construction of canals in the desert area commenced in 1962, and the first phase was completed in 1990. By this time there was a network of canals with a total length of more than 8,000 km. These canals have created water logging problem in vast areas. As a result of irrigation facilities soil structure has been changed with increased moisture retaining capacity. As a result of these environmental changes (man-made), a new vector (*Anopheles culicifacies*) is expanding in this areas, which was earlier dominated by *A. stephensi*. *A. culicifacies* remains active throughout the year. Such environment must have contributed in the increased incidence of malaria in the Thar Desert. However, the outbreak of malaria in the region, particularly in 1994 can not be associated with the changed environment due to canal irrigation network. Anomalously heavy rainfall due to El Niño Southern Oscillation created flooding conditions. And poor drainage in the Thar Desert resulted in the creation of breeding places. This has caused both high morbidity and mortality in 1994. In 1993, there were 354 deaths in India attributed to malaria. However, in 1994, some 372 deaths were officially reported in the four districts of Thar Desert, which accounts about 0.6% of India's population.

It should also be noted that the state of Punjab which has about 2.4% of India's total population with 98% irrigated cultivated area reports only 185 cases of *Plasmodium falciparum* with no death, compared with 88,310 *P. falciparum* cases with 452 deaths in the state of Rajasthan. Thus the hypothesis that the canal irrigation and water logging were the main reasons for malarial outbreak does not prove empirically.

5. Examples

5.1 In the Thar Dessert in 1982-1994

Based on thirteen years data, attempt has been made to study the association between rainfall conditions and the incidence of malaria. Table 3 shows that both the total annual rainfall and the number of rainy days are positively correlated with the total positive cases of malaria in the epidemic years of 1983, 1990 and 1994. Thus the hypothesis of meteorological correlation is proved positively (Akhtar & McMichael, 1996).

Attempt has also been made to correlate the average November temperature (Average of mean minimum and maximum in November) with the incidence of *P. falciparum* cases during 1982-1994. The correlation has been negative, as there is hardly any positive correlation in any year except during 1988 and 1989. Regarding the epidemic correlation with the rainfall in 1994, it should be noted that the total monsoon rainfall (June - September) in the year 1994, was one of the four years which experience the highest rains since 1871 (other years being 1917, 1944, 1990). Since 1982, the highest number of rainy days occurred (that is 51) only in 1994. Therefore the contention of Tyagi *et al.* (1995) that the epidemic occurred in the desert region irrespective of high rainfall does not hold significance. Hehir (1927) in his book "*Malaria in India*" published in 1927, noted the desert region with moderate epidemic zone (Hehir, 1927). He further said that malaria is markedly seasonal in character (usually maximum in autumnal) and moderately prevalent. However, Trent (2002) points out that, although malaria is preventable, there are a number of factors that hinder the successful control of the disease in India. While climate can affect the incidence of malaria, it is increasingly clear that man's economic activities and malaria control strategies play a far larger role in the incidence of the disease.

5.2 Heat wave mortality

The phenomenon of heat wave, its frequency and intensity causes serious illness and death. According to Intergovernmental Panel on Climate Change (IPCC,

Table 3 Rainfall, rainy days and incidence of malaria in Jodhpur.

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Average November temperature (°C)	24.0	21.0	23.0	24.5	24.0	24.6	23.2	24.2	23.0	23.0	22.4	24.1	22.7
Total annual rainfall (mm)	417	513	231	214	249	111	270	230	844	204	526	326	595
Number of rainy days	36	41	21	20	17	16	38	28	44	25	27	29	51
Total malaria cases	1,509	5,934	4,803	2,918	1,034	399	2,877	6,011	10,462	6,374	9,685	3,096	14,919
Percentage of <i>P. falciparum</i> cases to total cases	15	25	9	10	11	7	9.5	23	28.7	16.3	48.3	26.0	64.2

2001) an increase in the frequency or intensity of heat waves will increase the risk of mortality and morbidity, primarily in older age groups and the urban poor, particularly living in slums or squatter settlements.

In India, heat waves events and consequent deaths have been increasing year after year. In 1981 there were seven heat wave days with 63 deaths. These figures rose to 27 events and 1,658 deaths in 1998, and 70 events and 1,539 deaths in 2003.

According to World Health Organization (WHO, 1999) more than 4,000 farmers died due to heat waves since 2000; 1,200 in 2002, 2,400 in 2003, 200 in 2005 and 50 in 2006. In 1998, Orissa alone recorded 2,000 deaths due to heat waves leading to dehydration and heat strokes (Economic Times, 2007).

Based on the global climate, the first six years among the warmest years of past 140 years are from the recent decade (1998, 1997, 1995, 1990, 1999, 1991). The observed increase in the frequency of heat waves and severe heat waves actually and their persistency during 1990-2000 might have resulted from the increase in the decadal scale of global warming (Pasi *et al.* 2004).

Prominent among the studies on heat wave mortality was the paper by De and Mukhopadhyay (1998). These authors had examined severe heat wave conditions over the subcontinent in 1998 and assert that during the period March-June, when the normal temperatures are generally high over the Indian subcontinent, any further rise in temperature becomes a matter of concern to all the people. Each spells of high temperature sometimes claim heavy toll of human lives as well as live stock. The 1998 severe heat wave condition initially prevailed over northwest India. It then extended south and southeast towards Orissa and coastal Andhra Pradesh De and Ray (2000) reported these problems in the megacities.

An analysis of data on heat wave deaths reveals that the number of heat wave events and consequent mortality are on rise. These figures of mortality rose to 2,098 and 2,441 for the period 1979-1988 and 1989-1998 respectively and 3,023 for the period 1999-2004 as shown in Table 4.

Table 5 and Fig. 1 show the number of heat wave deaths for the period 1979-2004. It is evident from the table and the figure that in general the number of death have increased.

The severe heat wave condition of 1998, which was an El Niño year, initially prevailed over NW India. It then extended south-southeast towards Orissa and coastal Andhra Pradesh (De & Mukhopadhyay, 1998)

Table 4 Heat wave deaths in India.

Period	Number of deaths
1979-1988	2,098
1989-1998	2,441
1999-2004	3,023

During the month of March the heat wave conditions prevailed on three days in Jammu and Kashmir, 1 day each in west Rajasthan, Konkan, Goa and north interior Karnataka. This was the first time that day temperatures were 3 to 4 degrees appreciably above normal on 3 to 5 days in hills of west Uttar Pradesh, (now Uttarakhand), Jammu and Kashmir, Rajasthan, Saurashtra and Kutch, Rayalaseema, Tamil Nadu and Karnataka, on 1 and 2 days in Assam and Meghalaya, west Madhya Pradesh, Gujarat region and Maharashtra during the second fortnight of the month. The highest mortality was reported in 1998, i.e. 1,658 deaths. The major chunk was from Andhra Pradesh (514), Orissa (320), Rajasthan (322) and Bihar (161). During the month of May, about 1,579 people lost their lives in many parts of the country, according to a report by the India Meteorological Department (IMD, 1999).

Table 5 Heat wave deaths in India (1979-2004).

Year	Number of Deaths
1979	365
1980	106
1981	63
1982	11
1983	185
1984	58
1985	141
1986	155
1987	90
1988	924
1989	43
1990	2
1991	250
1992	114
1993	73
1994	234
1995	410
1996	17
1997	21
1998	1,658
1999	126
2000	55
2001	70
2002	806
2003	1,539
2004	117

Source: De and Mukhopadhyay (1998), updated and corrected by the author with the help of IMD Annual Reports on Disastrous Weather Events.

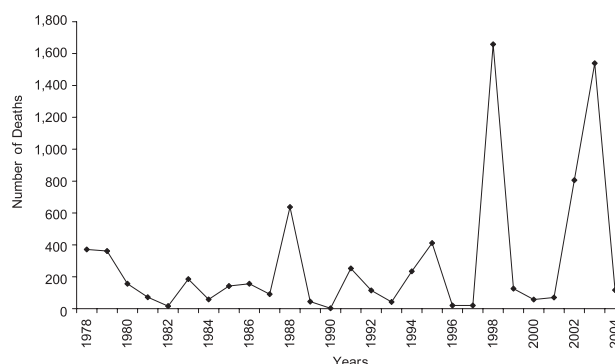


Fig. 1 Heat waves deaths in India.
(Source: IMD (1999))

Another striking feature of analysis of heat wave mortality data in India since 1979, that like European Heat wave of 2003, India too suffered the second highest mortality, i.e. 1,539 deaths in 2003 as shown in Table 5 and Fig. 1. Severe heat wave conditions prevailed on 11 days in coastal Andhra Pradesh and on 1 to 2 days in west Uttar Pradesh, Chattisgarh, Telangana, Rayalaseema and Tamil Nadu (IMD, 2004). Heat wave conditions prevailed on 4 to 7 days in Haryana, west Rajasthan, east Rajasthan, west Madhya Pradesh and 1 to 2 days in east Uttar Pradesh, west Uttar Pradesh, east Madhya Pradesh, Gujarat region, Saurashtra and Kutch, Vidarbha and Telangana (IMD, 2004). The largest toll was in Andhra Pradesh (1,300 deaths) followed by Orissa (141) and just 57 in Punjab, U.P., Rajasthan, Bihar and Madhya Pradesh together. However, the regions of Orissa, and coastal Andhra Pradesh suffer most in terms of heat wave mortality. Such heat wave conditions are attributed to both physical and human factors. Physical facts like

the blowing of north-westerly wind into the region, absence of sea breeze from Bay of Bengal, existence of an inversion layer in the atmosphere, rising level of albedo (the reflection of the surface), and numerous manmade causes including sleeping outdoor and lack of shelter etc. Erratic power and water supply is a common phenomenon in several states. In association with heat island phenomena, human health in the megacities is one of the serious problems (De *et al.*, 1998, 2000).

Was the 2003 heat wave phenomenon a global one? We need to analyse heat wave mortality data for other countries as well, in order to identify global heat wave mortality pattern in 2003.

5.3 Media reports on health

For the past couple of years, both television news channels as well as newspapers in India have been focusing on the significance of environmental change occurring in India. Almost everyday we see one or

5.5.2007

Now or never: Just 8 yrs to fight global warming

UN: Drastic Steps Needed To Check Climate Change

Nitin Sethi | TNN

New Delhi: The world cannot remain a fossil fool anymore, oblivious of the environmental destruction wrought as it guzzles fuels like coal and oil. It has just eight years to act and bring down the concentration of heat-trapping gases in the atmosphere if the rising global temperatures are to be contained between 2-2.4 degrees Celsius above the pre-industrial era, a hard-hitting report of the UN's apex body on climate change released on Friday said.

All countries, including India, will have to take drastic steps to shift from fossil fuels like coal and oil, which emit global warming gases upon burning, in order to avert a global crisis, the report said with a firmness and certainty that the experts of more than 100 countries have never asserted before. It has warned that any delay in action would lead to the temperatures rising alarmingly.

Nailing all quibbles on climate change from sceptics' chambers, the report warned that emissions of heat-trapping gases had increased alarmingly by 70% between 1970-2004, with levels of carbon dioxide increasing by 80% over the same period. In an ominous prediction, it noted that if the world continues to burn fossil fuels along current lines, then the dangerous emissions would rise by 90% by 2030.

The recommendations mark repudiation of arguments of both developing and developed countries. Countering the argument of the developing countries, like India and China, that reducing emissions would hit their economies, the report says that at worst, the global GDP would be blunted by about 3% by 2030 if it undertakes these emission cuts. It, however, admits that some countries will bear the brunt more than others.

On the other hand, developed countries have also been bluntly told that they would have to change their lifestyles and alter consumption patterns. These countries, with a mere 20% of the world's population, account for 50% of greenhouse gas emissions. The message for them is that mere adoption of technologies won't do.

► 'Climate report stunning', P 11
► Meltdown can be averted, P 19

Saving Mother Earth



Hot?

What is the report?

A 24-page UN document that will serve as the world's first roadmap for stemming greenhouse emissions. One hundred and five countries, including US and China, have endorsed it

What does it say?

World has **8 years** to stabilise greenhouse gases in the air at **445 ppm** to keep temperatures from rising more than **2°C** over pre-industrial levels

And the costs?

Technologies to arrest global warming in the coming decades will cost less than **0.1%** of world GDP

How do we do it?

ENERGY | Conversion from coal to gas and renewable power sources including hydro, nuclear, solar and wind
TRANSPORT | More fuel-efficient vehicles, including hybrids and cleaner diesel vehicles. More extensive use of rail and other public transport systems
AGRICULTURE | Improved crop and grazing-land management to increase soil carbon storage. Better rice cultivation techniques, livestock and manure management to reduce methane emissions
BUILDINGS/INDUSTRY | More efficient electrical gadgets. Better insulation and active solar design for heating/cooling

India too faces UN heat, House debate on May 8

TIMES NEWS NETWORK

New Delhi: As the UN apex body on climate change released its dramatic report on reducing greenhouse gases, India too woke up to the crisis with Parliament deciding to hold a full-day debate on the issue on May 8.

Responding to a calling attention motion moved by Jyotirmoyi Scindia (Congress) in the Lok Sabha on Friday, environment minister A Raja responded by repeating the much-touted, but internationally questioned, Indian position that only the developed countries should undertake emission cuts.

The UN Intergovernmental Panel on Climate Change (IPCC), releasing its third working group report in Bangkok on Friday, firmly asked all countries to cut their emissions drastically if the world is to be saved from rising temperatures and sea levels. It listed a host of key technologies and policies that India and other countries could adopt to reduce their emissions. The list addresses emissions from all energy guzzling sectors.

Undercutting arguments from India and China, the UN agency made clear in its report that countries would have to address not only the emissions from polluting industries and inefficient use of fossil fuels but also limit the heat-trapping methane released from paddy cultivation.

► India feels heat, P 9

Fig. 2 A clipping from a newspaper dated 5 May 2007.

two reports appearing in national newspapers concerning about temperature rise with special reference to heat wave conditions both in northern and southern India. The leading Indian newspaper 'The Times of India,' on 20th June, 2005 captioned that heat wave continues in East India focusing on the rise in temperatures between 44°C-47°C in Orissa. Once known for its sublime climate, the city of Bhubaneswar is perhaps encountering its worst summer in recent memory in 2005. The city has registered day temperature of over 46°C thrice within June 2005 turning it into the burning cauldron for prolonged period. The newspaper further stated that Purulia continued to be the hottest place (51.1°C) in West Bengal which claimed 23 lives in the state in the last two weeks. Over 450 persons have fallen ill, mostly due to dehydration in Purulia district. The heat wave forced the Patna district administration to extend schools summer vacation until June 30. Meanwhile, as many as 30 persons have been reported dead in the last 48 hours in Uttar Pradesh in North India, with temperature 46.8°C in Varanasi, and Allahabad coming a close second at 46.3°C followed by Lucknow at 45.7°C. The vast Indo-Gangetic plain spread across Uttar Pradesh is literally burning. According to this report, the 2005 summer was one of the hottest summers in Uttar Pradesh in the last 100 years.

In another news on 25th June, 2005, the caption in the 'Time of India' wrote "heat waves continues unabated in North India," with focus on developed states of Punjab, Haryana and Chandigarh in NW India as the scorcher confined people indoors. The death counts 35. Erratic power and water supply, however, forced people to stage demonstrations against the government.

On 11th October 2005, newspaper 'The Times of India' published a review of a WHO workshop on climate change and health, held at Mukteshwar, Almora which highlights that climate change brings health dangers to hills. These would include malaria, dengue, diarrhoea, typhoid, heat waves, injuries and death from more frequent glacial lake outbursts, extreme weather events, and the unseen trauma of living with heightened risks day after day. In mountainous areas, health systems are not geared to meet the new challenge. Some have not even begun to recognize there is a challenge and the health sector needs to be prepared. 'The Times of India' on 12th October 2005, quoted WHO estimates that climate change since the 1970s may already be causing 150,000 deaths globally each year. Many of those living in mountains are already beginning to feel the heat.

Continuing with publication of news items related to the impact of climate change, 'The Times of India' on 7th June, 2006 reports that the world's deserts are under threat as never before with global warming making lack of water an even bigger problem for the parched regions.

Frequent heat wave occurrence in different regions

of India has caused a serious problem. According to the report published on 7th February, 2007 in the 'Economic Times,' over 1,200 people died in 2002, 2,400 in 2003, 200 in 2005 and 50 in 2006 due to heat wave conditions prevalent across the Indian sub-continent. In 1998, Orissa alone recorded 2,000 deaths due to heat wave leading to dehydration and heat strokes. India has approached the WHO to cope with heat wave by associating with heat wave warning system.

6. Conclusion

Forecasting of epidemic malaria has been discussed already for the Punjab region in 1946 (Swaroop, 1946). It is evident from the discussion in this present paper that climate change will have a wide range of health impacts. It is now being seriously realized that increased regional climate extremes such as heavy rainfall, cyclones and droughts would lead to physical damage, population displacement and adverse health impacts. IPCC (2001) asserts with very high confidence that climate extremes associated with climate change would increase the risks of infectious disease epidemics, particularly in developing countries. As is evident malaria is still widely prevalent in India and an increase in temperature in the hilly/mountainous areas, it is feared that malaria may increase altitudinally.

The rural and urban areas of Orissa, parts of Uttar Pradesh, Bihar, Rajasthan and Andhra Pradesh, are major regions emerged in this paper which are affected by heat waves almost every year resulting in high human mortality.

Thus in the context of climate change impact, adaptation and mitigation, equity in resource availability has become an important issue to be incorporated in health planning. Therefore, it is important to focus on poverty alleviation measures, food security and sustainable environmental management. Provision of satisfactory housing with safe drinking water, adequate electricity supply, and hygiene/sanitation facilities can help people cope up with climate change scenario in which the occurrence of climate extremes may not be an unusual phenomena.

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