



RESEARCH ARTICLE

AN ANALYSIS AND OVERVIEW OF IMPACT OF CLIMATE CHANGE ON HUMAN HEALTH IN INDIA

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ABSTRACT

As of today climate change is one of the most important global environmental challenges of the present century. Water and food security indeed are key challenges under climate change as both are highly vulnerable to continuously changing climate patterns. As per the recent study it has been predicted that the average global temperature may increase by 1.4-5.8 degree Celsius and there would be also substantial reduction in agricultural yield and fresh water resources by the end of the 21st century. It is believed that approximately 75% of the Himalayan glaciers are on retreat and will also disappear by 2035. The rainfall could drop by 10% which would reduce drainage by 17% in Africa (Sub Saharan Africa) by 2050. The latest IPCC report concludes that climate change is projected to increase threat to human health, particularly in lower income countries. It will have implications on water supply, food production, air quality, coastal settlements and human health. As two third of the Indian population depends directly on the climate sectors like fisheries, agriculture and forests, it is also bound to have an adverse impact. The basic elements required for maintaining good health like portable water, clean water, adequate food and shelter can be affected by the changing climate. Recently India reported an increase in the incidence of decrease in crop production, vector borne diseases, more frequent extreme weather events which could be necessarily attributed to changing climate. Over the last 100 years or so, though India has contributed only 2 percent of the total carbon emissions from fossil fuel burning, still it is likely to experience greater effects from the 'extreme weather' events. Recent Heat waves in odisha and Andra Pradesh have caused an estimated 2000 and 3000 deaths respectively. Climate change is projected to bring increased temperatures, changing rainfall patterns, evaporation and salinization of water sources through rising sea levels. Over the years, water supplies stored in snow cover and glaciers are also projected to decline. This will also reduce water availability to populations supplied by melt water from some of the major mountain ranges. Addressing climate change will certainly need promoting adapting and mitigation strategies without hampering economic development, good scientific evidence as well as coordinated action by multiple stakeholders.

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INTRODUCTION

Today food and water scarcity are the biggest problem globally and it severely affects the arid and semiarid regions/countries. Climate change has resulted in increases in globally-averaged mean annual air temperature and variations in regional precipitation and these changes are expected to continue and intensify in the future (Solomon et al., 2007). The impact of climate change on the quantity and quality of groundwater resources is of global importance because 1.5–3 billion people rely on groundwater as a drinking water source (Kundzewicz and Doll, 2009). As per the fourth IPCC assessment report the knowledge of Ground waters recharge and of levels in both developed and developing countries is poor.

There has been very little research on the impact of climate change on groundwater' (Kundzewicz et al., 2007). Study of Global Climate Models (GCMs) projects significant changes to regional and globally averaged precipitation and air temperature, and these changes will likely have associated impacts on groundwater recharge (Kurylyk and MacQuarrie, 2013). IPCC report (2008) predicts that the climate changes over the next century will affect rainfall pattern, river flows and sea levels all over the world. Studies show that agriculture yield will likely be severely affected over the next hundred years due to unprecedented rates of changes in the climate system (Jarvis et al., 2010; Thornton et al., 2011). In arid and semi-arid areas the expected precipitation decreases over the next century would be 20% or more.

The accelerated increase in the greenhouse gases (GHG) concentration in the atmosphere is certainly a major cause for climate change. As per the IPCC (2007) report, the maximum growth in the emission of greenhouse gases (GHG) has occurred between 1970 and 2004, i.e. 145% increase from energy supply sector, 120% from transport, 65% from industry, 40% from change in land use patterns and during this period global population increases by 69%. As per the WMO (2013), the world experienced unprecedented high-impact climate extremes during the 2001–2010 decade that was the warmest since the start of modern measurements in 1850. Moreover, survey of 139 National Meteorological and Hydrological Services and socio-economic data and analysis from several UN agencies and partners conducted by WMO concluded that floods were the most frequently experienced extreme events over the course of the decade. Extreme weather could be a manifestation of global climate change. In its fourth assessment report the United Nation's inter-governmental panel on climate change has concluded that overall climate change is projected to increase the threat to human health, particularly to lower income populations, predominantly with tropical/sub-tropical countries. Nearly two third of the population in India are depending directly on the climate sensitive sectors such as fisheries, agriculture and forests. The projected climate change under various scenarios is likely to have many implications on water supply, food production, biodiversity and livelihoods. During the last few years extreme weather events such as severe storms, drought and flood have claimed thousands of lives and have also adversely affected the lives of millions in terms of economic losses and also damage to property. Human beings are exposed to climate change through changing weather patterns either directly or indirectly through changes in air, water, food quality and quantity, agriculture, livelihood and infrastructure. Climatic conditions affect diseases transmitted through water and via vectors such as mosquitoes in addition to changing weather patterns. Climate-sensitive diseases are among the largest global killers that can cause excess mortality and morbidity directly or indirectly. Season-wise, maximum rise in mean temperature was observed during the post-monsoon season, followed by winter season, pre-monsoon season and monsoon season.

An overview of the health effects of climate change

Global Scenario: Climate change affects health in many ways. The relationship between climate change and human health is multidimensional. The fourth assessment report of IPCC has already identified three areas in which human health has already been affected by climate change. These are: i). Alteration in distribution of some infectious disease vectors ii) Seasonal distribution of some allergenic pollen species and iii) Increased heat wave related deaths. The potential future effects of global climate change include more frequent wildfires, longer periods of drought in some regions and an increase in the number, duration and intensity of tropical storms. Global climate change has already had observable effects on the environment. Glaciers have shrunk, ice on rivers and lakes is breaking up earlier, plant and animal ranges have shifted and trees are flowering sooner. Effects that scientists had predicted in the past would result from global climate change are now occurring: loss of sea ice, accelerated sea level rise and longer, more intense heat waves.

Indian Scenario: In terms of adverse health impact will be mostly borne by the poor and developing countries as the

major brunt of global climate change event though the rich and industrialized countries account for maximum greenhouse gas emission. Though India has contributed only 2 per cent of the total carbon emissions from fossil fuel burning over the last 100 years, still it is likely to experience greater effects from the 'extreme weather' events. Major health effects due to changing climate can be broadly classified as follows:

- Air pollution related health affects
- Extreme weather related health effects
- Water and food borne diseases
- Vector borne diseases
- Major effects of food and water shortages
- Psycho-social impacts on displaced populations
- Health impacts from conflicts over major access to vital resources

Major objectives of the study

- To study the extreme weather-related health effects
- To know the pollution related health effects
- To study the water and food borne diseases and vector borne diseases
- To analyze the effects of food and water shortages
- To know the Psycho social impacts on displaced populations
- To know the health impacts from conflicts over access to vital resources
- To analyze the major policy implications

Extreme weather related health effects

Eighteen heat-waves were reported in India between 1980 and 1998, with a heat-wave in 1988 affecting ten states and causing 1300 deaths. Heat-waves in Odisha, India, in 1998, 1999 and 2000 caused an estimated 2000, 91 and 29 deaths respectively and heat-waves in 2003 in Andhra Pradesh, India caused more than 3000 deaths. In June 2005, there was another record in the Eastern Indian state of Odisha with an unusual mercurial rise in summer, the capital city of Bhubaneswar recorded the highest temperature of 46.3 degree Celsius which was 10 degrees above normal, leading to a heat wave. Floods are an annual feature in Bihar but the 2004 floods were unique for its severity. The Indian metropolitan city of Mumbai was besieged with India's heaviest downpour of the century in July 2005, killing nearly 600 people. According to the Indian Meteorological department, it was the heaviest ever (83.82 cm) in India of last 100 years, breaking the record of previous highest rainfall in India at Cherrapunjee in Meghalaya recorded on 12 July 1910.¹⁴ On one hand, Mumbai was being flooded; Cherrapunjee which was once well known for being the wettest place in the world received less than average rainfall in June and July with distressing situation subsequently. The record-breaking Mumbai rain or heat waves in Odisha may not have a direct causal association with global climate change but at the same time, it cannot be ignored as 'simple local aberrations.' Populations in high-density urban areas with poor housing will be at increased risk with increasing frequency and intensity. The record-breaking Mumbai rain or heat waves in Odisha may not have a direct causal association with global climate change but at the same time, it cannot be ignored as 'simple local aberrations.' Populations in high-density urban areas with poor housing will be at increased risk with increasing frequency and intensity.

Pollution related health effects

Air Pollution related Health effects: Due to human activities concentrations of air pollutants are on rise. Air pollution concentrations are certainly the result of interactions between variations in atmospheric circulation features, topography, wind and energy use. Interaction among the pollutants may get modified too as their formation depends on these factors as the changing climate may alter the temperature and humidity. Some air pollutants demonstrate weather-related seasonal cycles.¹ Increased air temperature can lead to earlier pollen season and altered distribution of allergen and thereby leading to asthma episodes. There is stronger evidence for the health impacts of particulate matters on morbidity and mortality¹, so increasing concentrations would have significant negative health impacts. The association between daily variation in meteorological conditions and mortality has been described in studies from a wide range of populations in temperate climates. These studies show that exposure to temperatures at either side of a 'comfort range' is associated with an increased risk of mainly cardio-pulmonary mortality.

Increase in other disease measures manifested by increased outpatient attendance at hospitals has been associated with extreme temperatures. Cardiovascular disease (CVD) has the best characterized temperature-mortality relationship, followed by respiratory disease and total mortality in temperate countries. These relationships are supported by strong evidence for direct links between high and low temperatures and increased blood pressure, viscosity and heart rate for CVD and broncho-constriction for pulmonary disease. Likewise, seasonal fluctuations have been observed for tropical climates, despite the less-pronounced intra-annual climatological variation that is mainly related to seasonal differences in precipitation. Nevertheless, the number of studies focusing on tropical climates is limited, especially for Asian countries. Tropical countries have been associated with excess summer mortality; this is often explained by a high prevalence of infectious and diarrhoeal disease. India is at a higher risk with wide variation in temperature and higher level of air pollutants. The IPCC fourth assessment report on human health also concludes that the frequency and intensity of heat waves increases the number of deaths and serious illness.

Water and food borne diseases: Climate change related alterations in rainfall, water quality and surface water availability could affect the burden of water related diseases. These diseases can be classified by route of transmission, thus distinguishing between water-borne (ingested) and water-washed diseases (caused by lack of hygiene). Diarrhoeal disease is one of the most important causes of disease burden, particularly in developing countries. There is strong evidence that diarrhoea, particularly the one caused by the bacteria and protozoan pathogens which predominate in developing regions, is highly sensitive to variations in both temperature and precipitation over daily, seasonal, and inter-annual time periods. It is, therefore, very likely that long-term climate change will lead to consistent changes in diarrhoeal rates. Climate change can result in increased temperatures in both ocean water and ambient air. Rise in sea level due to increased temperatures can lead to coastal flooding, which can force the communities to use contaminated water, inadequate sanitation systems, or trigger migration into areas with insecure water and sanitation availability which can lead to the spread of Cholera.³⁰ Warm water, moderate salinity, and number of

aquatic invertebrates are the conditions influenced by climate change which promote the growth of Cholera species.

Vector borne diseases: Weather certainly affects vector population dynamics and disease transmission with humidity and temperature considered as key variables. Climate changes are known to increase the availability of water during monsoon also alter the air temperature besides other changes. Hence certainly there would be an increase in the major population of the vectors in the altered climate. Clean water is known to promote breeding of vector mosquitoes such as anophelies (Malaria), culex vishnui group (JE vector) and aedes (Dengue, Chikungunya) whereas polluted water bodies promote breeding of culex quiquefasciatus (Filariasis vector). Vector-borne diseases are currently prevalent in the tropics and subtropics and relatively rare in temperate zones of India. Experience with mosquito-borne epidemics in the past has indicated that increased water availability especially during post-monsoon period can lead to marked increased population of the vector mosquitoes. Under certain circumstances, it is possible that mosquitoes which do not normally transmit a disease could play a role in transmission of vector-borne disease like Japanese encephalitis (JE), especially if high densities of the particular species occur. As the vector life cycle is strongly influenced by temperature and humidity, an altered climate with higher temperature and humidity will shorten the development period of the vectors leading to larger production of vector population.

Effects of food and water shortages: Changing patterns of rainfall and rising temperatures are necessarily projected to decrease crop yields in many developing countries, stressing upon the food supplies. Both chronic nutritional and acute problems are associated with change and climate variability. The effects of drought on health include deaths, malnutrition (under-nutrition, protein-energy malnutrition and/or micro-nutrient deficiencies), infectious diseases and respiratory diseases.¹ Malnutrition is considered as the single most important risk factor for health, accounting for an estimated 15 per cent of total disease burden in terms of death-adjusted life-years (DALYs). While multiple biological and social factors influence malnutrition, the fundamental determinant is the availability of staple foods. For the populations that depend on subsistence farming, or do not have sufficient income to buy food, this situation is expected to bring malnutrition. In turn, malnutrition and under-nutrition increase the severity of many infectious diseases, particularly among children. Under-nutrition and related disease is currently the greatest contributor to the global burden of disease, killing over 3.5 million people a year, mostly children in developing countries. Millions of more people are projected to become at risk of food insecurity and the health consequences of malnutrition. Increase in global temperature is likely to cause droughts and associated disruptions in agriculture and water supplies. Drought diminishes dietary diversity and reduces overall food consumption, and may, therefore, lead to micro-nutrient deficiencies. In Gujarat, India, during the drought in the year 2000, diets were found to be deficient in energy and several vitamins. In this population, serious effects of drought on anthropometric indices could have been prevented by public-health measures¹. Developed nations probably have the resources and the infrastructure to adjust, but in the less well-developed nations, it is likely that these effects will result in famines, thereby contributing to malnutrition and increased susceptibility to a variety of infectious diseases.

Psycho-social impacts on displaced populations: Expected increases in the frequency and severity of floods and storms will result in the destruction of homes, agricultural lands, medical facilities and other essential services, impacting particularly on people residing in slums and other marginal living conditions. As the global temperatures rise coupled with stronger storm surges; so will the sea level, eventually placing many thousands of hectares of land under water leading to more frequent and more severe coastal flooding. Much of the India's populations live on coastlines that will be threatened, and as the coastlines disappear, their residents will be forced to migrate. The consequent destruction of homes and communities will eventually force unprotected populations to seek safer ground, often increasing environmental and social pressures in their new locations. Major delta areas of Asia are likely to be subjected to stress associated with sea-level rise, changes in water regimes, saltwater intrusion, siltation, and land loss. Low-lying coastal areas will be at the forefront of impacts; the cities like Mumbai and Chennai have witnessed significant environmental stresses in recent years. There are 13 coastal states and Union territories susceptible to sea-level rise in the country, with about 84 coastal districts affected by tropical cyclones. States like Tamil Nadu, Andhra Pradesh, Odisha and West Bengal, Gujarat and Union Territory of Pondicherry are most affected by cyclonic activities. Crowding due to population displacement is likely to exacerbate already encountered housing problems in the mega-cities in developing nations. In addition, noise, overcrowding and other possible features of unplanned urbanization may increase the prevalence of mental disorders, such as depression, anxiety, chronic stress, schizophrenia and suicide.

Health impacts from conflicts over access to vital resources: In the long run, the greatest health risks may not be from natural disasters or disease epidemics, but from the slow build-up of pressures on natural, economic and social systems that sustain health. These are already under stress, particularly in the developing country like India. Climate change is projected to bring changing rainfall patterns, increased temperatures, evaporation, and salinization of water sources through rising sea levels. Over the years, water supplies stored in glaciers and snow cover is projected to decline. This will reduce water availability to populations supplied by melt water from major mountain ranges¹. Climate change-related increases in temperature could increase the rate of snowmelt and reduce the amount of snowfall, if the winter is shortened. If climate change does alter the rainfall pattern in the Himalayas, the impacts could be felt in the downstream states of India resulting in drought like situation. A major trigger for population movements are drought and the consequent loss of livelihoods particularly from rural to urban areas. With much dependence on climate-sensitive sectors such as water, agriculture and forestry and natural resources, India may face a major threat from scarcity of vital resources.

Policy implications: Precisely at a time when India is confronted with development imperatives, we will also be severely impacted by climate change. With close economic ties to natural resources and climate-sensitive sectors, India may face a major threat and require serious adaptive capacity to combat climate change. With 27.5 per cent of the population still below the poverty line, reducing vulnerability to the impacts of climate change is essential. In response to the predicted changes in public health due to climate change, our policymakers need to work to strengthen the health care

systems along with water and wastewater systems. Adaptation will require diverse strategies like inter-sectoral coordination which could include physical modification to the built environment and improved housing and building standards.³⁶ In order to address some of the predicted changes as well as those are taking place in India in an effective manner, more emphasis is required on the following policies:

- Strengthening Service delivery mechanisms and health systems
- Provision of sanitation and drinking water facilities to all
- Provision of funding for low income communities with poor sheltering and high exposure/risk to heat and cold waves
- Educating people about climate-related diseases to combat and overcome them

Conclusion

The present paper shows the linkages between climate change and human health are multi-layered and complex and predictions of the future health impacts of climate change are still very uncertain. In India, over the past hundred years or so the annual mean temperature has increased. Projection of the future climate change scenario shows catastrophic events will exhibit an increase in frequency and intensity resulting in enormous impact on human life in terms of death toll and disease epidemic. Climate change is happening and emissions are bound to increase due to growing economy of India. Therefore, addressing both mitigation and adaptation is important. Even the developed nations are struggling to cope up with the challenges posed by the changing climate; India needs to put more efforts to counter the same. Climate changes have started showing its impact on water resources and agricultural yield worldwide. Majority of the countries in arid and semiarid areas totally depend on precipitation and rivers originating in tropical and temperate regions. The overall water stress is continuously increasing and due to climate changes a sharp decline in precipitation is expected in these regions. Studies also predict reduction in frequency and escalation in the intensity of rainfall, which will result in frequent drought and floods. Agricultural sector and food securities are threatened and if the basic adaptive measures such as changes in crop pattern, crop breeding and types and innovative technologies, which use less water are not used global food production especially in arid and semi-arid areas will further decline. The present situation in the majority of the arid and semiarid countries is not satisfactory. These countries are not able to fulfill the required demand for water and food for people. The implementation of recycling and reuse of wastewater is a good option in these countries. Unsustainable depletion of groundwater will likely be worsened by reduced surface water infiltration in arid and semiarid areas and the increase in intrusion of salt water to coastal aquifers from sea level rise will further reduce the availability of usable groundwater. Considering the increasing trend of impact of climate change on human health, adoption of mitigation measures like strengthening health systems and service delivery mechanisms through early monitoring, disease surveillance, vector and disease control, and health insurance to counter the same becomes imperative. Investment in research and development, health risk assessment studies, vulnerability mapping studies, establishment of baseline

conditions, scenario modeling and adoption of clean development mechanisms, etc. are the need of the hour.

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