Review Article

Climate Change and its effects on Vector Borne Diseases in India

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Abstract

The world is witnessing Climate change. This change has already started affecting air quality, food production, water supply, coastal settlements and human health. Vector-borne diseases account for over 17% of all infectious diseases. There is increasing evidence about the impact of climate change on Vector Borne Diseases. We collected secondary data in September 2017 from published articles, journals, reports, and books on this major issue to discuss the effects of climate change on VBDs in India through this article. This paper will briefly review the changing epidemiology of the most important vector-borne diseases in India.

Keywords: Carbon Emissions, CO_2 Concentrations**,** Temperature changes, Precipitation changes and Vectors

Introduction

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity.[1] Climate change occurs in hundreds or even millions of years. Climate change may result from both natural and human causes though the human causes appear to be increasingly responsible for climate change over the past few decades. Naturally occurring Greenhouse Gases (GHG) include water vapour, carbon dioxide, ozone, methane, clorofluro carbon (cfc) and nitrous oxide, together create a natural green house effect. Human activities are increasing GHG levels in the atmosphere and thus causing Global Warming.[2] Atmospheric carbon dioxide levels, which have remained steady at 180-220 ppm for the past 420,000 years, are now close to 370 ppm and rising.[3] Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. According to Intergovernmental Panel on Climate Change (IPCC) 2013- The globally averaged combined land and ocean surface temperature data as calculated by a linear trend, show a warming of 0.85 [0.65 to 1.06] °C, over the period 1880 to 2012.[4] Figure -1. Climate change is projected to bring changing rainfall patterns, increased temperatures, evaporation, and salinization of water sources through rising sea levels.[5]

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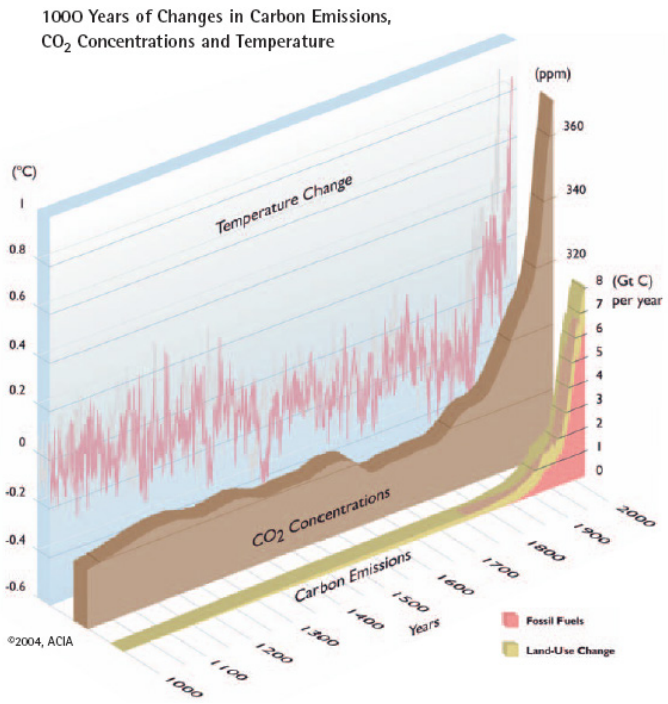

Source: PPT on Health Climate change and WHO, Figure from Arctic Climate Impact Assessment (ACIA) 2004

Figure 1.1000 Years of Changes in Carbon Emissions, CO_2 Concentrations and Temperature

Methodology

Secondary data was collected in September 2017 from published articles, journals, reports, and books on this major issue. This article will use and discuss the same to see if there is indeed effect of climate change on VBDs in India.

Climate change affects human health

Climate change affects human health mainly by three pathways:

- Direct impacts by increasing the frequency of extreme weather-conditions - heat, drought and heavy rainfall
- Effects mediated through natural systems such as [6] - air pollution-related health effects, water and food-borne diseases and Vector-borne diseases
- Effects that are heavily mediated by human systems - effects of food and water shortages, psycho-social impacts on displaced populations and the health impacts from conflicts over access to vital resources

Extreme weather-related health effects

There has been an increase in heat waves, draughts, and floods in last three decades. There have been 18 heat-waves reported in India between 1980 and 1998. Heat-waves in Odisha, in 1998, 1999 and 2000 caused an estimated 2000, 91 and 29 deaths respectively and heat-waves in 2003 in Andhra Pradesh caused more than 3000 deaths. Draughts in Maharashtra have been increasing since 2013. There are annual floods in Bihar but the 2004 floods were unique for its severity. There is increasing exposure to coastal flooding – such as in Mumbai in July 2005 killing nearly 600 people. Delhi had experienced worst summer in 33 years in 2012.[7] Figure - 2

Figure 2.Climate Change and its Effects on Human Life

Projected climate change in India

The Indian Network of Climate Change Assessment (INCCA) report projected climate change scenario for India by the year 2030, in four vulnerable sectors: Himalayan region, Northeastern states, Western ghats and Coastal regions.[8]

Major Vector-borne diseases (VBDs) in India

Vector-borne diseases are illnesses caused by pathogens and parasites in human populations. Vectors are living organisms that can transmit infectious diseases between humans or from animals to humans. TABLE -1. There is increasing evidence about the impact of climate change on Vector Borne Diseases, and some of it can be explained by the fact that the insect vectors of these diseases are ectothermic and hence temperature affects their vectorial capacity and the extrinsic incubation period (EIP) of pathogens.[9] The main VBDs in India are Malaria, Kala-azar (Visceral Leishmaniasis), Japanese Encephalitis, Lymphatic Filariasis (LF), Chikungunya and Dengue.

Table 1.Vector Borne Diseases – their Pathogens and Vectors

Disease	Pathogen	Vector	Transmission
Protozoan			
Malaria	Plasmodium falciparum, vivax, ovale, malariae	Anopheles spp. Mosquitoes	Anthroponotic
Kala azar/ Leishmaniasis *	Leishmania spp.	Lutzomyia & Phlebotomus spp. Sandflies	Zoonotic Reservoir: Domestic animals - cow, buffalo, goat, dog
Trypanosomiasis *	Trypanosoma brucei gambiense, rhodesiense	Glossina spp. (tsetse fly)	Zoonotic
Chagas disease *	Trypanosoma cruzi	Triatomine spp.	Zoonotic
Viral			
Dengue *	DEN-1,2,3,4 flaviviruses	Aedes aegypti mosquito	Anthroponotic
Yellow fever	Yellow fever flavivirus	Aedes aegypti mosquito	Anthroponotic
Encephalitis (West Nile, Lyme, etc.)	Flavi-,alpha- and bunyaviruses	Culex mosquitoes and ticks	Zoonotic Reservoir: Domestic pigs and wild birds
Filarial nematodes			
Lymphatic filariasis *	Wuchereria bancrofti Brugia malayi, timori,	Anopheles, Culex, Aedes mosquitoes	Anthroponotic
Onchocerciasis *	Onchocerca volvulus	Simulium spp. Blackflies	Anthroponotic

*WHO neglected tropical disease

Climate Change and its Effects

Temperature Effects

On Vector

The survival may decrease/increase depending on the species. There are changes in the susceptibility of vectors to some pathogens and changes in rate of vector population growth. E.g. Higher temperature and humidity will shorten the development period of the vectors leading to larger production of vector population (JE mosquitoes) as well as there are changes in feeding rate and host contact

On Pathogen

At higher temperatures there is decreased extrinsic incubation period (EIP) of pathogen in cold blooded (ecto-thermic) vector by affecting its Vectorial Capacity.[10] There are changes in the transmission season and in geographical distribution of disease vectors and VBDs, for example, by rendering previously endemic areas unsuitable and previously non-endemic areas suitable for their existence and reproduction. [11] There is decreased viral replication.

Vector Survival

There are direct effects of temperature on mortality rates. At low temperatures, lifecycle lengthens and mortality outstrips fecundity.[12]

Precipitation Effects

On Vector

The survival may increase as increased rain may increase larval habitat, heavy rainfall events can synchronize vector host-seeking and virus transmission and increased humidity increases vector survival and vice-versa. Excess rain can eliminate habitat by flooding. Low rainfall can create habitat as rivers dry into pools (dry season malaria) and it can increase container-breeding mosquitoes by forcing increased water storage.

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On Pathogen

There are a few direct effects but humidity affects malarial parasite development.

Vector Activity

Increased Relative Humidity (RH) increases Vector activity - increases transmission rates whereas heavy rainfall decreases Vector activity.

Effects on transmission of VBDs

Some diseases will spread to areas where they are currently absent. E.g. Dengue, Chikungunya, West Nile Virus and Zika Virus Disease are emerging in countries where they were previously unknown. Some diseases will disappear from areas where they currently exist. Intensity of transmission of some pathogens will change locally, and yearly patterns will vary with changes in weather patterns. Human activities will strongly influence transmission in response to climate change.

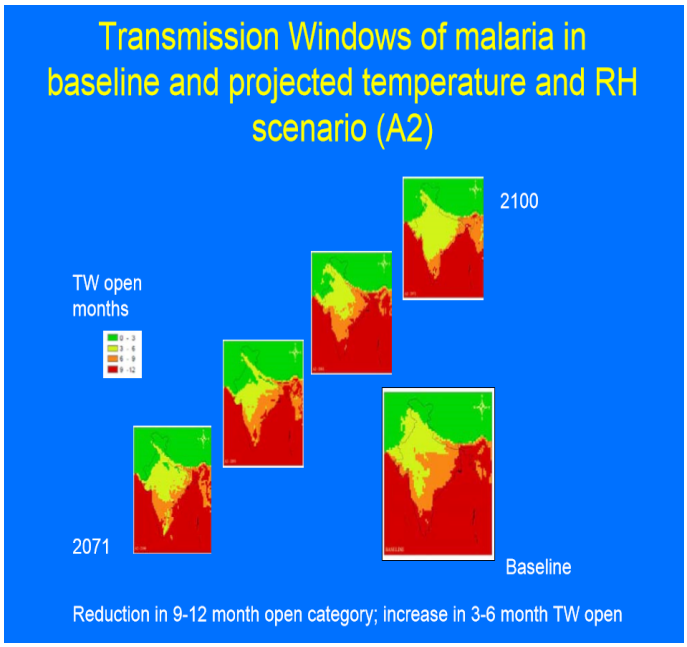
Malaria

About 400-500 million cases of malaria and more than 1 million malaria-related deaths occur globally each year. Several factors have caused the global resurgence of malaria, including the emergence of insecticide and drug resistance, human population growth and movement, land-use change, and deteriorating public health infrastructure.

Over the past 15 years, Malaria burden has reduced in India. Both the parasite and the mosquito that houses the parasite are susceptible to temperature changes. At physiological tolerance limit temperatures, a small increase in temperature can kill the parasite, thereby decreasing malaria transmission. Reductions in transmission intensity in endemic areas might lead to greater proportions of the population losing immunity, resulting in epidemics in later years.[13] At lower temperatures, a small increase in temperature can greatly increase the risk of malaria transmission due to increased numbers of mosquitoes.

Changes in temperature and precipitation patterns have the potential to expand the geographical range of malaria into temperate and arid parts of South Asia. For example, in India malaria distribution is expected to expand to higher latitudes and altitudes.[14] Rainfall alone accounted for about 45 per cent of the variation in malaria transmission.[15]

Analysis of Baseline and projected climate parameters for Malaria and Dengue was done at national level using A2 and A1B Scenario of Providing Regional Climate for Impact Study (PRECIS) model. Studies undertaken in India with A2 scenario on malaria reveal that the transmission window in Punjab, Haryana, Jammu & Kashmir and northeastern states are likely to extend temporally by 2–3 months and in Odisha, Andhra Pradesh and Tamil Nadu there may be reduction in transmission windows. Thus there will be reduction in 9-12 month open category and increase in 3-6 months Transmission Window (TW) open. Figure - 3



Source: PPT found at www.moef.nic.in/sites/default/files/Impacts_Ramesh%20C%20Dhiman.pdf

Figure 3.Transmission Windows of Malaria (Scenario A2), in India

By the 2050s, the geographic range of malaria vectors is projected to shift away from central regions toward southwestern coastal States (Maharashtra, Kerala, and Karnataka) and northern States. The duration of exposure (transmission window) is likely to widen in north and west India, and shorten in south India.[16]

Kala-azar (Visceral Leishmaniasis) and Post Kala-azar Dermal Leishmaniasis (PKDL)

Visceral Leishmaniasis/ Kala-azar is a parasitic disease prevalent in 4 states Bihar, West Bengal, Jharkhand and Uttar Pradesh. The link between re-emergence of kala-azar in northern parts of India appears to be due to changing climatic conditions which needs to be elucidated.

Japanese Encephalitis

In India, the JE virus was first isolated in humans in North Arcot (presently Vellore) Tamil Nadu in 1955.[17] In 1973 large outbreak took place in Bankura and Burdwan, West Bengal. Cases have been reported from different parts of the country. In 2006, a major outbreak of viral encephalitis reported from Gorakhpur and eastern Uttar Pradesh, where JE was known to be endemic. The virus identified as causing AES include: Herpes virus, Influenza A virus, West Nile virus, Chandipura virus, Mumps, Measles, Rubella, Varicella-Zoster, Nipah and others. Incidence of JE in India has increased in eastern Uttar Pradesh in the last five years and the epidemiology has also posed problems as cases of Acute Encephalitis Syndrome also occur in JE endemic areas.

The National Program for Prevention and Control of JE/ AES for 60 high burdened districts of five states viz., Assam, Bihar, Tamil Nadu, Uttar Pradesh and West Bengal was approved by the Cabinet on 18th October, 2012

Lymphatic Filariasis (LF)

Lymphatic filariasis, commonly known as elephantiasis, is a neglected tropical disease. Lymphatic filariasis (LF) has been historically endemic in India (16 states and 5 UTs).

Chikungunya

The first reported outbreak of Chikungunya was in 1963 in Calcutta (now Kolkata), with transmission continuing until 1973.[18] Kolkata, Pondicherry and Chennai in Tamil Nadu, Rajamundry, Vishakapatnam and Kakinada in Andhra Pradesh, Sagar in Madhya Pradesh and Nagpur in Maharashtra. Only after 2-3 decades the virus re-emerged in 2005, and has since spread rapidly, with more than one million cases reported. Since 2006 reports of large scale outbreaks of fever caused by Chikungunya in several parts of India have confirmed the re-emergence of this virus in the country with 13.9 million clinically suspected and 2001 laboratory confirmed cases. [19] In 2016, epidemic occurred in Delhi. Suspected deaths due to Chikungunya and associated diseases in elderly people were reported by Sir Ganga Ram Hospital and Apollo Hospitals in Delhi. Major issue of concern is urbanization in the context of VBD, particularly dengue and chikungunya.

Dengue

Dengue has also been a significant problem, with more than 50 dengue outbreaks reported in India since 1960. [20] Impact of climate change on dengue also reveals increase in transmission with 2°C rise in temperature in northern India. The thresholds of temperature and relative humidity for indigenous transmission of dengue need to be redefined.[21]

In a study using A2 scenario of PRECIS model, transmission windows for dengue transmission (12–40°C temperature) were projected, which show climatically whole country is suitable; water availability and Life style are the major determinants. Figure – 4

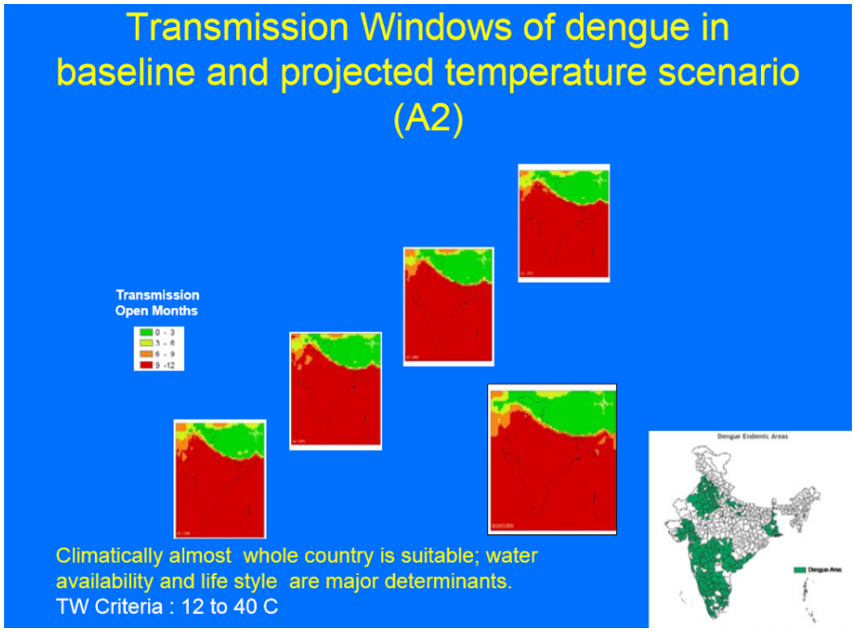


Figure 4.Transmission Windows of Dengue (Scenario A2), in India

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Vector-borne diseases account for over 17% of all infectious diseases.[22] The National Vector Borne Disease Control Programme (NVBDCP) data from 2007 to 2016 shows that there is a slight decrease in Malaria burden whereas the burden of Dengue and Chickungunya is on a rise. TABLE – 2.

Table 2.Climate change in India and rise of some VBDs - Dengue and Chickungunya

Disease	Year	Cases	Deaths
Malaria	2007	1.59 million	1023
	2016	1090724	331
	2017	486059	44
Kala azar	2007	28941	105
	2016	6245	Nil
	2017	2969	Nil
Japanese Encephalitis	2007	5149	677
	2016	1676	283
	2017	1066	115
Dengue	2007	28292	110
	2016	**129166**	245
	2017	36635	58
Chikungunya	2007	59535	Nil
	2016	**64057**	Nil
	2017	22828	Nil
Filariasis	2007	600 million (Toatl Burden)	Nil

Source NVBDCP (data for 2017 is only up to August 2017)

Conclusion

The Climate change in India has affected the VBDs in either direction. Dengue and Chickungunya have been on the rise whereas burden of Malaria has shown a slight decrease for now. Risk factors in terms of water availability, storage practices and life style have inreased the Transmission Window for Dengue, rendering the whole country vulnerable for the whole year. also need to determined. Special focus should be given to the four vulnerable sectors as mentioned in INCCA report. As adaptation measures, early warning system for preventing outbreaks is the need of the hour.

More and more awareness should be created for masses about human activities that are increasing GHG levels in the atmosphere and thus causing Global Warming. To conclude, along with integrated vector control measures for tackling problem of vector-borne diseases it is essential to address issues related to climate change with utmost priority.

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