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3. Climate change and diseases: the double jeopardy

Global warming and the resulting climate instability portend ill for public health and well being. Climate change encompasses temperature changes on global, regional and local scales, and also changes in the rainfall, winds, and possibly ocean currents.[i] There is evidence that our world is warming in recent years, and is happening due to increasing levels of gases such as carbon dioxide, methane and sulphur dioxide, collectively known as green house gases (GHGs) in the atmosphere. Since these absorb the infrared radiation of the sun, a higher level of these gases increases global temperature. Scientists are convinced that this warming is happening due to GHGs, most of which emanate from the burning of fossil fuels such as coal and oil to produce electricity or to fuel automobiles.[ii] United Nation's Intergovernmental Panel on Climate Change (IPCC), - a body of 2,500 experts all over the world appointed by governments in 1988- in its first full report for five years, argues that current warming "is unlikely to be entirely natural in origin" and that "the balance of evidence suggests a discernible human influence on global climate."[iii] Rising global temperatures are expected to raise sea level, and change precipitation and other local climate conditions. Changing regional climate could alter forests, crop yields, and water supplies.[iv]

Climate change could also affect human health through increase in heat-stress mortality, tropical vector-borne diseases, urban air pollution problems, and decrease in cold-related illnesses that human activities are causing such changes.[v] These impacts of climate change have considerable potential to cause significant loss of life, affect communities, and increase health-care costs and lost workdays. Areas where malaria is currently endemic could experience intensified transmission (on the order of 50-80 million additional annual cases, relative to an estimated global background total of 500 million cases). Some increase in non-vector-borne infectious diseases- such as salmonellosis, cholera, and giardiasis- also could occur as a result of elevated temperatures and increased flooding.[vi]

Such climatic changes would have its impact on India also. We are already seeing some changes in our climate, such as heat waves are getting more and more intense. Mr Lal at Centre for Atmospheric Sciences (CAT) at Indian Institute of Technology (IIT) feels that global warming has come to India, given its land use changes, deforestation, GHGs emissions and industrialisation. He goes on to add that rainfall pattern had also been changing over the country. Extreme events such as peak temperatures and flash floods were becoming more frequent too. Orissa witnessed an extremely high summer temperatures last year, followed by a virtual drought during the monsoon season. According to Mr Lal's estimates, warming over India could be to the extent of two to three degree celsius by the end of the next century, which could have a major impact on the country's food production and water reserves.[vii] Thus, global warming should be a cause of concern for Indian scientists and climate experts.

3.1 Climate change: real and happening

Last year, the group of climate experts advising the world's governments reported that earth is definitely getting hotter, and that the burning of fossil fuels- coal, oil and gas, and the destruction of forests, is almost certainly responsible. The earth's atmosphere is like a canopy of glass panes, which traps a portion of the sun's heat, thus preventing it from escaping back into space. This trapped heat keeps the earth nice and warm. This phenomenon is known as the "Greenhouse effect" wherein the earth and its atmosphere act like one giant greenhouse. Scientists have recently found that the release of GHGs from burning fossil fuels, burning vegetation to clear land and various agricultural practices could force the atmosphere to become warmer that it would otherwise. Most climate experts believe that global mean temperatures will likely rise at a rate of 0.5° Fahrenheit (0.3° centigrade) per decade if current emissions trends continue. At this rate, temperatures would rise about 1.8°F (1°C) by 2025 and 5.4°F (3°C) before the end of the next century.[viii]

While the United States ranks first in the emission of carbon dioxide (See table 1.1), Canada tops the list in the per capita (per head) contribution of carbon dioxide to GHG emissions (See table 1.2 below). Among developing countries, China and India too are significant contributors to GHG emissions (See table 1.3). Though the total contribution of carbon monoxide from China and India is significant, their per capita emission is much less as compared to developed countries.

Table 1.1 Total anthropogenic carbon dioxide emissions for 1990

Country	Carbon dioxide emission (Giga Gms)
United States	3,801,100
China	2,163,040
Japan	1,040,629
Germany	985,155
United Kingdom	603,372
India	584,866
Canada	416,899

Source: Dr M Lal 1999, Personal communication with Raj Kishore, Indian Institute of Technology, Delhi.

Table 1.2 Aggregate emissions of green house gases (carbon dioxide equivalents) for 1990

Country	Emission of Green House Gases

	(GHGs) (Giga grams)
United States	4,856,992
China	2,397,640
Germany	1,179,107
Japan	1,137,804
India	1,005,421
United Kingdom	778,058
Canada	554,009

Source: Dr M Lal 1999, Personal communication with Raj Kishore, Indian Institute of Technology, Delhi

Table 1.3 Per capita carbon dioxide emissions for 1990 in a select list of countries

Country	Per Capita carbon dioxide Emission (tones)
Canada	16.03
United States	15.20
Germany	12.50
United Kingdom	10.86
Japan	8.49
China	1.89
India	0.69

Source: Dr M Lal 1999, Personal communication with Raj Kishore, Indian Institute of Technology, Delhi

Not a wolf cry

Swedish chemist, Svante Arrhenius was the first to identify the problem of global warming in 1896. He maintained that human activities like driving cars, burning coal to heat homes, felling of trees to build houses and make paper, and raising cattle have increased the atmospheric concentrations of key greenhouse gases. Studies of the climate over the last century indicate that the world is already warming. Sea levels are already rising. The 10 hottest years in history have all occurred since 1980. The International Panel on Climate Change (IPCC)- a body of 2,500 experts all over the world appointed by governments in 1988- estimated that oceans may rise by as much as a metre by the end of the next century, as ice caps and glaciers melt. This would mean the total disappearance of entire island nations, and the flooding of coastal zones. Climate scientists are now predicting a temperature rise over the next century, which could be greater than any since the end of the last ice age, and are warning that the effects of this could include the spread of deserts, drought, famine and widespread species extinction.[ix]

There is sufficient data to suggest that the warming is for real (See figure). The warmest month of January since 1860 was in 1998. In fact, all months of the year surpassed the temperature of the corresponding warmest month in 140 years- an indication of global warming. This is reflected in the progressive upsurge in global surface temperature (see figure). There has been perceptible trend in warming sine 1980. In fact, 1998 was 0.4°C warmer as compared to the average temperature base period of 1961-90. Although accurate temperature records date back only century back, tree rings, ice core samples and fossil pollen records indicate that the 1990s have been the hottest decade in 600 years.[x]

One of the starkest manifestations of global warming has been felt in Alaska. Two Eskimo communities, Yup'ik and Inupiat, testify that the climate is indeed changing. "About 15 years ago, it started getting warmer. The snow now melts much faster," Benjamin Pungowiyi, a young Alaska hunter says, and continues, "The ice freezes later and breaks up a lot sooner."[xi] Hannah Mendenhall points out, "The tundra is not as spongy as it used to be. Now I can hear it crackle when I walk on it and it's dry. We are beginning to get insects that are not usually of this climate. We are getting so warm that they are comfortable coming up this way."

Climate change-induced temperature rise is not unique to the Arctic Circle. It has been observed in India too. The last few decades have been warming steadily. The rate of warming for India is almost the same as predicted for the global rate. Rainfall pattern has been erratic in recent times. While the normal rainfall has been decreasing in most places, excess rainfall has been increasing in the 35 meteorological subdivisions in India (See figure). Most unsettling is the fact that the monsoon (which causes most of the rain in India) aberrations are also being seen to occur in a region-specific manner. For instance, Punjab and other northern states such as Haryana and Delhi have shown an increase of 44 per cent and 83 per cent respectively during 1991-98, whereas in the Northeastern states, the rainfall during monsoons have decreased by as much as 28 per cent. (See figure)

3.2Impact of climate change

Climate influences many of the key determinants of health: it leads to extremes and violent weather events; resurgence of disease organisms and vectors; affects the quantity of air, food and water; and the stability of the ecosystems on which we depend. Climate change can have both direct and indirect human health impacts. Indirect impacts arise from changes in temperature patterns, which may disturb natural ecosystems, change the ecology of infectious diseases, harm agriculture and fresh water supplies, exacerbate air pollution levels, and cause large-scale reorganisation of plant and animal communities.[xii] (See figure below: Direct and indirect health impacts of climate change)

Figure: Direct and Indirect Health Impacts of Climate Change

Mediating process	Health outcome
Direct	
Exposure to thermal extremes	Altered rates of heat-and cold-related illness and death
Altered frequency and/or intensity of other weather events	Deaths. Injuries, psychological disorders; damage to public health infrastructure
Indirect	
Disturbances of ecological systems	
➢Effects on range and activity of vectors and infective parasites	Changes in geographic ranges and incidence of vector-borne diseases
➢Altered local ecology of waterborne and foodborne ineffective agents	Changed incidence of diarrhoeal and other infectious diseases
➢Altered food (especially crop) productivity, due to changes in climate, weather events, and associated pests and diseases	Malnutrition and hunger, and consequent impairment of child growth and development
Sea level rise, with population displacement and damage to infrastructure	Increased risk of infectious diseases, psychological disorders
Levels and biological impacts of air pollution, including pollens and spores	Asthma and allergic disorders; other acute and chronic respiratory disorders and deaths
Social, economic, and demographic dislocations due to effects on economy, infrastructure, and resource supply	Wide range of public health and nutritional impairment, infectious diseases, civil strife

Source: Anon 1998, Environmental Change and Human Health, in World Resources 1998-99, p 68.

Direct impacts

a) Heat Waves: One of the impacts of global warming is an increase in the number and severity of heat waves. In both New York and Shanghai record show that daily mortality rates increase sharply once temperatures exceed a certain threshold. During intense heat waves, the death toll attributed to heat stress can be surprisingly high, as occurred in Chicago in July 1995, when heat stress killed 726 people during a 4-day heat wave.[xiii]

This year India also experienced temperatures high above the normal and several have died as a result of the April-May heat wave. In 1998, major parts of the country extending from north India, parts of northeast India and the northern parts of peninsular India experienced severe heat wave during the second half of May. Even south interior Karnataka and some stations of Tamil Nadu were under the grip of severe heat wave conditions during this period. Chennai recorded the second highest maximum temperature (44°C) of the present century on 24 May, which was 8°C above the normal.

The highest ever recorded maximum temperature (45°C) had occurred in Chennai on 21 May 1910. Experts believe that the summer of 1998 was the worst in the past fifty years. It took a toll of nearly 1300 human lives of which 650 lives were lost in Orissa alone. During this period a few stations in Rajasthan experienced temperature in excess of 49° C. Figure *** depicts the variation of maximum temperature of some selected stations from 15-31 may 1998. Table below shows that the number of the heat wave days as well as number of human lives lost due to heat wave during may and June in the present decade (1989-1998) are comparatively higher than in the previous decade (1979-1988).[xiv]

Table: Heat wave days and deaths in the Indian subcontinent

Year	No. of heat wave days	States affected	Lives lost
1979	16	Orissa, Andhra Pradesh, Gangetic West Bengal, Uttar Pradesh, Bihar	365
1980	7	UP, Maharashtra, Tamil Nadu, Andhra Pradesh	106
1981	7	UP, MP, Bihar,	63
1982	4	UP	11
1983	11	Bihar, Punjab, UP, Maharashtra	185
1984	11	UP, Punjab, Maharashtra	58
1985	5	Punjab, Bihar	141
1986	8	Andhra Pradesh, Punjab, Rajasthan, Himachal Pradesh, Bihar	155
1987	6	Orissa, Punjab, Haryana, UP	90
1988	21	Rajasthan, Gujarat, Saurashtra and Kutch, UP, Punjab	924
1989	15	Rajasthan, MP, Maharashtra	43
1990	6	Rajasthan	-
1991	10	Rajasthan, MP, Gujarat, Maharashtra	250
1992	13	Rajasthan, MP, Haryana, Bihar, UP, Maharashtra	114
1993	13	Punjab, haryana, Rajasthan, UP	73
1994	25	Punjab, Haryana, Rajasthan, MP, UP, Maharashtra	234
1995	29	Haryana, Rajasthan, Punjab, UP	410
1996	9	Rajasthan, Haryana, UP	17
1998	27	Punjab, Rajasthan, Gujarat, UP, Maharashtra. Orissa, Andhra Pradesh, South Tamil Nadu	1300

Surprisingly during 1997, no heat wave condition prevailed over any part of the country.
Source: U S De and R K Mukhopadhyay 1998, Severe heat wave over the Indian subcontinent in 1998, in perspective of global climate, in *Current Science*, Vol 75, No 12, 25 December, pp 1310-1311.

According to R K Singh, Lecturer, Civil Engineering Group, BITS, Pilani, "Temperature change may have an impact on several major categories of disease including cardio-vascular, cerebrovascular and respiratory diseases."[xv] High temperature makes it tough for the thermo regulatory system of the body to maintain the equilibrium temperature of the body. Although there tends to exist an inverse relation between cardio-vascular and cerebro-vascular deaths and temperature in range of -5°C to 25°C, high mortality due to strokes is observed in cases with temperature above 25°C. Therefore, cardio-vascular and stroke deaths are likely to be major contributors to any excess mortality due to global warming.[xvi]

Conversely, a potential health benefit of warmer global temperatures could be fewer cold-related deaths, as winters become milder. A recent British study estimated that by 2050, an increase in the average wintertime temperature by 2.0°C to 2.5°C, as predicted by some climate models, might result in as many as 9,000 fewer cold-related deaths per year in England and Wales. Yet, experts believe that the decrease in mortality will be negligible as compared to the increase in mortality resulting from global warming; studies indicate that higher mortality is generally associated with heat waves than cold spells. (See table: Estimates of Summer Heat –Related Deaths in 2020 in selected Cities under a Climate Change Scenario) The table shows that during a typical summer, 78 extra deaths occur in Atlanta from heat-related causes and, assuming no acclimatization (acclimatization means that over a period of time the population gets used to the climate in which it has been living), this number rises to 191 deaths. But, in case the population gets acclimatized, the mortality still rises to 96 deaths.[xvii]

Table: Estimates of Summer Heat –Related Deaths in 2020 in selected Cities under a Climate Change Scenario

City	Present mortality[a]	Range of mortality with respect to population not getting acclimatized and that getting acclimatized respectively
United States		
Atlanta	78	191-96
Dallas	19	35-28
Detroit	118	264-131
Los Angeles	84	205-102
New York	320	356-190
Philadelphia	145	190-142
San Francisco	27	49-40
Canada		

Montreal	69	121-61
Toronto	19	36-0
China		
Shanghai	418	1,104-833
Egypt		
Cairo	281	476-0

a.Raw mortality data
Source: Anon 1998, Environmental change and human health, in *World resources 1998-99*, New York Oxford, Oxford University Press, p 68.

b) Natural disasters: In addition to more frequent heat waves, global climate change is expected to result in greater weather variability overall. In particular, climatologists believe that relatively small changes in the average global climate in the future could produce large changes in the frequency of extreme weather events, such as hurricanes, violent thunderstorms, and windstorms. Through flood and wind damage, these natural disasters already exact a heavy burden in the destruction of lives and property.[xviii] A major reason for this spate of natural disasters is the increase in deforestation all throughout the globe. For instance, Central America loses between 2 to 4 per cent of its remaining forest cover every year. By destroying forests, damming rivers, filling wetlands, and destabilizing the climate, human actions are unraveling the strands of a complex ecological safety net that protects against storms and other calamities. Clearing forests also exacerabtes drought in dry years by allowing the soil to dry out more quickly. Other pressures- poverty, population growth, and inequitable land rights- have forced people into vulnerable areas such as steep hillsides and unprotected riverbanks.[xix]

The year 1998 set a new record for disasters worldwide; damage from weather-related disasters reached a record high of more than $92 million. Thousands of people were killed, and millions were displaced from their homes. In January, an ice storm in Canada and New England caused $2.5 billion in damages, bringing down thousands of miles of power lines and nearly wiping out the region's sugar maple industry. In June, 10,000 people were killed by a cyclone in Gujarat, India. Vast forest fires raged out of control over 52,000 square kilometers in Brazil, 20,000 square kilometers in Indonesia, and 13,000 square kilometers of Siberia. Turkey, Argentina, and Paraguay experienced massive flooding. Storms, droughts, fires, and floods plagued almost every region in the world.[xx] Ironically, the United Nations had designed the 1990s as the "International Decade for Natural Disaster Prevention", hoping to stem the rising toll taken by natural disasters worldwide. Instead, the past ten years may be known as the International Decade of Disasters, as the world experienced its most costly spate of storms, floods, and fires in history.

These events of 1998 provided a lesson to humanity: that any form of development- from the huge Tehri dam in the earthquake-prone Himalayas to luxury homes on fragile coasts- which ignores ecological reality and social inequality is prescription for disaster.

Unless nations, including India, are able to build or rebuild along a path of sustainable development that emphasizes maintaining and restoring healthy ecosystems, they risk even greater exposure to the devastation of unnatural disasters in the future.

c) Rising sea levels: Rising sea levels, another expected consequence of global warming, could adversely affect the health and well being of coastal inhabitants. Sixteen of the world's largest cities with populations of more than 10 million are located in coastal zones, and coastal populations are increasing rapidly worldwide. The IPCC projects that sea level will rise between 0.3 and 1.0 meter by 2100, with a best-guess estimate of 0.5 meter. The most immediate threat from such a rise would be to those who live directly on the coast, in low-lying areas such as river deltas, or on small island nations such as the Maldives, the Marshall islands, Kiribati, and Tonga, where land is virtually all within a few meters of sea level already. Delta regions such as the Ganges-Bramaputra delta in Bangladesh, the Nile delta in Egypt, or the Niger delta in Nigeria could also suffer a similar fate.[xxi] Bangladesh suffered its most extensive flood of the century in the summer of 1998, when two-thirds of the country remained inundated for months. While annual floods are part of a natural cycle in this low-lying country, which encircles the meandering deltas of the Ganges and Brahmaputra Rivers, the 1998 floods reached near-record levels and did not recede for months. More than 30 million people were left temporarily homeless, 10,000 miles of the roads were heavily damaged, and the annual rice harvest was reduced by 2 million tons. Overall damage estimates exceeded $3.4 billion. In future, rising sea levels caused by climate change are projected to make Bangladesh even more vulnerable to flooding.[xxii] Recent study projects that a 1-meter sea rise could inundate 17 per cent of Bangladesh's total land area and displace some 11 million people.[xxiii]

d) Effects of El Nino: El Nino, which occurs over the cycle varying from two to seven years, is marked by the rise of surface temperature of water in the equatorial Pacific. The air above the warm water rises forms rain-bearing clouds, which bring increased precipitation in the surrounding regions. As the even progresses, the area of warming expands, larger and larger areas experience increased rainfalls. In contrast to this, some areas face a dry weather. Thus El Nino causes floods in some areas and droughts in others. As El Nino completes its cycle, it brings in its wake the opposite effect called La Nina. During La Nina, ocean temperatures in the Pacific are unusually colder.

The 1997 El Nino event was the strongest of the century, and its impacts were felt worldwide. In a forecast by the US National Oceanic and Atmospheric Administration (NOAA), it was stated that sea surface temperature (SST) was 2-3°C higher than the normal. The forecast predicted India and Indonesia would be drier than normal while the climate in central Chile, Uruguay, southern Brazil, Peru and central Argentina would be wetter than the usual.[xxiv] And that was what happened. Extreme droughts and fires occurred in Asia, across Mediterranean nations, in the Amazon, in Mexico's tropical rainforest, in Central America and in California and Florida in the United States. Eye

irritation, respiratory illness and cardiovascular disease rose dramatically in many of these regions. Increased incidence of cholera occurred in many of the tropical regions affected by floods and drought. Heat waves killed thousands in India, and hundreds in Central Europe and the United States. In China and Bangladesh, devastating floods occurred as El Nino waned.[xxv]

e) Air pollution: Global warming is not acting in isolation. It comes in addition to existing environmental stresses such as acid rain and air pollution. Burning of fossil fuel and increasing automobiles are cited as reasons which cause/aggravate climatic changes. One such climatic change caused by them is acid rain. The phenomenon of rain is caused when heat from the Sun's rays on the surface of the seas, lakes and rivers induces evaporation. The water vapour formed in the process rises to a height where it condenses into moisture. If ambient conditions prevail it comes down as rain. But in the case of acid rain, water vapours reaches the atmosphere, condenses, and reacts with atmospheric gases like SO2 and NOx. When it rains, these atmospheric pollutants are deposited on the soil, vegetation, surface water or reservoirs. The deposition ultimately results in damage because of the acidity of the pollutants. Acidic rainwater liberates mercury from the soil which can hinder brain development during the foetal stage. Fish-eating birds and humans acquire mercury by eating fish with high levels of the metal in them. The fish in turn ingest microorganisms, which consume mercury released by acid rain in the water. Acid rain also releases aluminium and cadmium. Cadmium can cause kidney disorders, besides accumulating in the outer layer of the kidney, causing wounds. Aluminium on the other hand, causes problems for kidney patients. In dialysis- the process of purifying the blood when the kidneys malfunction- it enters the blood stream directly without first having passed the body's normal protective barriers. This may cause skeletal and brain damage. It may also cause Alzheimer's and Parkinson's diseases.

Apart from the risk of acid rain, climate change could influence air pollution profiles- and the health effects that come from exposure to polluted air- by altering the rate of chemical reactions in the atmosphere that destroy pollutants, or by influencing the factors such as wind and precipitation that regulate how pollutants accumulate or disperse. For example, higher temperatures favour the formation of pollutants like ground-level ozone- the main constituent of smog. Preliminary calculations by U.S EPA show that 4°C increase in ambient air temperatures in the San Francisco Bay area would likely increase ozone levels by 20 per cent and double the size of the area that does not meet national air quality standards. Higher temperatures would also increase the evaporation of volatile liquids such as gasoline or organic solvents, again adding to the urban smog problem.[xxvi] Children are at higher risk from such increases than adults because their lungs are still developing and they spend more time outdoors in summer when ozone levels are higher.[xxvii] Although uncertainties remain, it is likely that an increase in global temperatures would worsen urban air quality problems by increasing the number of non attainment areas (areas that do not meet the US EPA health-based

standards), increasing the rate of natural emissions of hydrocarbons, and increasing the formation of acidic material such as sulfates.

Scientists have discovered to their surprise that haze of air pollution about the size of the United States covers the Indian Ocean in the wintertime, and they say it may have important implications for global climate change and the regional environment of both Asian and the tropical ocean. The brownish haze is composed of several kinds of minute byproducts from the burning of fossil fuels for industry and transportation. The scientists say these elements, including soot and sulphur droplets, are blown out over the ocean from the Indian subcontinent, China and Southeast Asia during the winter monsoon, when prevailing winds sweep down from the Himalayas and out to sea. In the late spring and summer, the winds reverse as part of the summer monsoon and blow the haze back across the land, where it combines with monsoon rains and falls out of the atmosphere as acid rain. Although no one reason has been cited as the cause of the haze, but the scientists are predicting climate change to be a major reason.[xxviii]

Apart from the smog and haze, changes in regional wind and rainfall patterns accompanying climate change could also affect air pollution levels. If winds increase in a given area, they would tend to disperse and dilute air pollutants, thereby lowering human exposures. By contrast, a decrease in winds with an increased tendency to from local inversion layers- where warm, still air aloft traps pollutants close to the surface- would increase pollution exposures. Likewise, in areas where rainfall increases, pollutant loads may decline, since precipitation scours many pollutants from the air. A decrease in rainfall, on the other hand, may increase pollution levels since fewer pollutants are washed out of the atmosphere.[xxix]

3.3 Health impacts of climate change

a) Vector-borne diseases: Mosquitoes are quite sensitive to changes in temperature and rainfall and are among the first organisms to extend their range when environmental conditions become favourable. Thus, higher temperatures could influence the incidence of diseases such as malaria, dengue fever, yellow fever, and several types of encephalitis. Cold temperatures are often the limiting factor in mosquito survival, so any increase in minimum winter temperatures would likely extend mosquito ranges into temperate regions or higher altitudes where they do not survive.[xxx]

Higher temperatures also speed the life cycles of both the mosquito and the disease organisms they harbour and make adult mosquitoes bite more often. At 30°C, the dengue virus takes 12 days to incubate in the *Aedes aegypti* mosquito, but only 7 days at 32°C. The shorter incubation period translates to a potential threefold higher transmission rate of the disease. Higher temperature also produce smaller adult mosquitoes that must feed more often to develop an egg batch, which in turn increases

the chances for diseases transmission.[xxxi] The world's major vector-borne diseases are shown in Table. The diseases most often cited, as potential adverse consequences of climate change are dengue fever and malaria. The World Health Organisation (WHO) has already recorded "quantitative leaps" in malaria incidences in the recent years.[xxxii] Table indicates that there are a number of other diseases that have received less attention but are likely to change in prevalence and range with climate change.

Table: The world's major vector-borne diseases ranked by population currently at risk

Disease	Causative agents	Vectors	Population at risk (Millions)	Population infected (millions)	Likelihood of altered distribution with climate change
Dengue fever	Viruses	Mosquitoes	2,500	50/year	++
Malaria	Protozoa	Mosquitoes	2,400	300-500/year	+++
Lymphatic filariasis	Nematodes	Mosquitoes	1,094	117	+
Schistosomiasis	Flatworms	Water snails	600	200	++
Leishmaniasis	Protozoa	Sandflies	350	12	+
River blindness	Nematodes	Blackflies	123	17.5	++
Trypanosomiasis (sleeping sickness)	Protozoa	Tsetse flies	55	0.25-0.3/year	+

Abbreviations: +, likely; ++, very likely; +++, highly likely.
Source: Nathan Y Chan 1999, An integrated assessment framework for climate change and infectious diseases, in *Environmental Health Perspectives*, Vol 107, No 5, May, p 330.

Malaria: Malaria is the most prevalent vector-borne disease globally and causes 1 million to 2 million deaths annually. Temperature and humidity are among the most important factors for disease transmission and the extrinsic incubation period (EIP) of the parasite shortens dramatically at temperatures between 20°C and 27°C. The EIP is defined as the number of days between the vector's ingestion of an infected blood meal and the point that it becomes capable of transmitting infection.[xxxiii] Rough models of the spread of malaria affected by global warming show that malaria prevalence may increase by 50 million to 80 million cases per year with an associated 3°C rise in average global temperature by the year 2100.[xxxiv] 1990s in India are already seeing a resurgence of this diseases. From 2.2 million cases in 1993, the incidence of malaria

has grown to more than 3 million cases in 1997. And, it is still growing. In the year 1998, a total of 9,37,536 malaria cases were reported from the States till the month of October.[xxxv]

Malaria incidence related to local climatic change has been observed in Rwanda, when in 1987, extension of malaria into higher altitudes resulted after record high temperatures and rainfall.[xxxvi]Argentina provides an example of the complex changes in malaria distribution that climate change could bring. Currently, most of Argentina lies just south of the zone in which malaria occurs. But if global warming increases rainfall in central Argentina and makes it semitropical, as models project, the malaria-carrying mosquitoes might be able to expand into the pampas and savanna regions, introducing malaria to these areas.[xxxvii] Based on such observations, a relatively small increase in winter (minimum) temperature would likely facilitate the spread of malaria into large urban highland populations that are currently malaria-free and immunologically naïve, such as Nairobi, Kenya, and Harare, Zimbabwe. [xxxviii]

The impacts of such global warming and increase in rainfall are also visible in India that might lead to an increase in malaria incidence. India is already witnessing an upsurge in malaria cases and a disease that was thought to have been eradicated has bounced back. 1990s have also witnessed an increase in the temperature, with 1998 being the hottest. Correspondingly, the rainfall pattern has been erratic in recent times. Such climatic changes are favourable for the spread of diseases such as malaria and dengue.

Dengue: Currently, dengue viruses are being transmitted in the tropics between 30°C north and 20°C south latitude, since frosts or sustained cold weather kills adult mosquitoes and over wintering eggs and larvae. Warming trends, therefore, can shift vector and disease distribution to higher altitudes, as was observed in Mexico when dengue reached an altitude of 1700m during an unseasonably warm summer in 1988. Consistent with predictions associated with warming in mountain regions, dengue fever is now being reported at higher elevations at 1240 meters in Central America and 1700 meters in Mexico. The mosquito vector has been reported at 2200 meters in the Colombian Andes. It may also be moving south, as its presence in northern Argentina and Australia suggest. Dengue fever (DF) and dengue hemorrhagic fever (DHF) now occur regularly in Asia and throughout Latin America.[xxxix]

1996 witnessed a major dengue outbreak in the Capital of India. In this epidemic, there were in all 10,000 cases with about 400 deaths.[xl] Delhi still is potential site for more of such outbreaks. The vector of dengue has also started moving towards the mountain regions. Whereas earlier dengue outbreaks were not reported from the mountain regions of Jammu, a dengue outbreak occurred there in 1974. Recently, another epidemic was reported from Ludhiana in 1996, the first of its kind in that region.[xli] This clearly shows that dengue as a disease is spreading to new areas within the country thus posing public health hazard.

Other vector-borne diseases: Other vector-borne diseases such as schistosomiasis, Chagas disease, sleeping sickness, river blindness, and various strains of encephalitis all could change their ranges and patterns of infection in the course of climate change. For example recent modeling of the response of schistosomiasis to current global warming trends suggests that an additional 5 million cases will appear per year by 2050.[xlii]

Onchocerciasis, or "river blindness", is a blackfly-borne disease primarily found in West Africa and, to lesser extent, in Latin America. Climate plays an important role in the occurrence of onchocerciasis since the vector requires fast-flowing water for successful reproduction, and the adult vector can spread by wind. A recent study found out that if temperature and precipitation changes across portions of West Africa as predicted by some global circulation models, blackfly populations might increase by as much as 25% at their current breeding sites.[xliii]

African trypanosomiasis, or "sleeping sickness", is carried by tsetse flies, whose distribution depends on vegetation cover. Researchers in sub-Sahara Africa have correlated vegetation type to the population densities of tsetse flies using satellite images to predict a large extension of regions at risk for this disease, assuming a 3°C mean monthly temperature rise.[xliv] Tick-borne diseases are also sensitive to climatic conditions but favour cooler temperatures.[xlv]

b) Emerging infectious diseases: Infectious diseases are emerging, resurging and undergoing redistribution on a global scale. According to a 1996 WHO report, at least 30 infections new to medicine have emerged in the past 20 years. While biological changes, under-funded public health systems, and social inequities are contributing to the emergence of infectious diseases, environmental changes, including global warming and greater weather volatility, are apparently contributing to this global resurgence and may do so to an even greater extent in the future. [xlvi]

Increase in temperature correlate with increased populations of some microorganisms that cause waterborne diseases, such as *Vibrio cholerae* bacterium, which causes cholera. Higher ambient temperatures foster the growth of pathogens that thrive in or on food, such as *Salmonella*.[xlvii] The cholera organism is known to live in sea-borne plankton that blooms as the sea surface warms. The 1991 outbreaks in Peru is cited as circumstantial evidence for this chain of events, because it spread extremely quickly and took place when an El Nino had warmed Peru's coastal waters.[xlviii] During a recent examination of satellite data, National Aeronautics and Space Administration (NASA) scientists have discovered an association between the height and temperature of sea surface and outbreak of cholera in Bangladesh in 1992 and 1995. The research is in collaboration with Rita Colwell and her colleagues at the University of Maryland, who recognised that cholera cases in Bangladesh surge in spring and autumn when coastal

waters are at their warmest. Work in her laboratory showed that cholera-carrying plankton thrive in these conditions. Thus everytime there is a rise in sea level, there are chances of **cholera** outbreak in Bangladesh, and this has happened in the past.[xlix] Climatic changes have caused excess of rainfall in many Indian cities, due to which floods occur. At present also, Bihar is flooded with water and the infrastructure has broken down. Such floods are a major cause of spread of water-borne diseases in India.

c) Ozone depletion, CFCs and Skin disorders: Chloro Fluoro Carbon (CFC), also called freons 11 and 12 that are produced by human activities are one of the major cause for green house effect. (See table below) Although their production started only by 1930, they have accumulated in the atmosphere to an alarming extent that is leading to the warming of the atmosphere and ozone depletion.[l] The increase of CFCs in the atmosphere, leading to global warming will increase UV radiation in the atmosphere, effecting thus the immune systems and leading to infectious diseases. Susceptibility to important skin infections such as leishmaniasis or leprosy might be increased by greater exposure to UV light. The UV radiation affects the immune system of the skin and hence there might be an increased number of cases of **skin cancer**. Human skin includes three major cell types, all of which are susceptible to sunlight-induced cancer. These cell types are basal cells, squamous cells, and melanocytes. The DNA of all these cells are particularly vulnerable to ultraviolet light. Once UV radiation penetrates below the surface of the skin, it alters the DNA structure of these cells, leading to unhealthy cell growth that results in skin cancer. The damaging effects of sunlight can occur many years before tumours appear. Light-skinned people living in parts of the US exposed to intense ultraviolet rays during the summer months are most prone to skin cancer, because they produce less of the melanin pigment that protects dark skin from ultraviolet damage.[li]

In India, the problem of skin cancer is not so grave. “Skin cancer is not a problem in India. It accounts for only 0.5 per cent of all cancers in the country. But, that in no means that if global warming happens and we are more exposed to sunlight, we will still remain unaffected,” says Dr Bidhu K Mohanti, additional professor, Radiation Oncology, Institute Rotary Cancer Hospital, All India Institute of Medical Sciences, New Delhi.

Apart from it, the increased UV exposure has the potential to interact synergistically with climate change in case of some communicable diseases. Other minor effects are increased incidence of skin disorders, such as prickly heat and fungal skin disorders such as ringworm and athlete’s foot as a result of increased temperature and humidity.[lii] The CFC releases show how mankind affects the climates. Since CFCs are being released at an alarming rate, it is important to come out with measures to reduce their production and use in several spheres of life.

Table: Contributors of CFCs

Contributing	**Amount**	**in**

agents	percentage
Aerosols	25
Rigid foam insulation	19
Solvents	19
Air conditioning	12
Refrigerators	8
Flexible foam	7
Others	10

Source: T V Subramaniam, S Kumaran and S Sreenath 1996, Chloro Fluoro Carbon, the Green House Gas and the Future Prediction, in *Indian Journal Of Environmental Protection*, Vol 16, No 9, September, p 641.

d) Effect on agriculture: In addition, the changing temperature and rainfall patterns and the increasing CO2 levels projected to accompany climate change will undoubtedly have important effects on global agriculture, and thus on human nutrition. A variety of effects will inevitably occur, and these will vary greatly by region, resulting in more favourable agricultural conditions in some areas and less favourable conditions in others.[liii]

The rise in the level of water in the sea will reduce fertile lands in many areas and may be even deltic lands of rivers thus affecting agricultural production. Similarly, the overflow of seawater will displace millions of people who will naturally migrate to safer areas. The possibilities are, (i) they might migrate to settle in cultivable lands thus reducing cultivable lands; (ii) they might migrate to settle in forested areas in which case cutting forests will lead to ecological imbalance thus affecting productions; and other option is that they may move to other nearby states/countries creating political tension.[liv]

According to D N Borthakur, former vice chancellor, Assam Agricultural University, “Rise in temperature will adversely affect crops, livestock and other living forms.” It has been stipulated that the rise in temperature will affect most of the developing countries located between 30°N and 30°S latitudes. Thickly populated countries such as India will naturally suffer the most. Food production in the tropical areas, specially in the major grain producing areas, such as, South east Asia, South and mid-China, Indo-Gangetic and Brahamaputra plains, southern and coastal India will be affected. Scientists from 25 countries had recently submitted a report to the United Nations on the effects of global warming on crop production. The report states that climate change will increase the disparities in cereal production between the developed and developing countries.[lv]

On the positive side, higher atmospheric CO2 levels are expected to have a “fertilizing” effect on some plants, increasing their growth rate and cutting transpiration rates, reducing their water demand. Increasing temperatures may bring longer growing seasons to some high-latitude farming regions, increasing yields and expanding the

range of crops that can grow there. Higher rainfall in some areas might enable higher production from unirrigated land and more water for irrigation in these areas.[lvi]

On the negative side, higher temperature and diminished rainfall could reduce soil moisture in many areas, particularly in some tropical and midcontinental regions, reducing the water available for irrigation and impairing crop growth in nonirrigated regions. For example, dried summers and more frequent hot spells in the North American Corn Belt might reduce yields substantially, although it might extend the corn-growing region northward. Reduced rainfall in already arid regions like sub-Saharan Africa could have very negative consequences for agriculture in areas that can ill afford to lose production. In Senegal, for example, one study predicts a 30-per cent yield decline with 4°C rise in temperatures and no change in rainfall from current levels. The negative effects of climate change on agriculture in poor countries could put an additional 40 to 300 million people at risk of hunger by 2060.[lvii]

e) Effect on ecosystems: Perhaps the greatest long –term danger to human health from climate change will be the disruption of natural ecosystems, which provide an array of services that ultimately support human health. Biotic systems- whether in forests, rangelands, aquatic environments, or elsewhere- provide food, materials, and medicines; store and release fresh water; absorb and detoxify wastes; and satisfy human needs for recreation and wilderness. They are also intimately involved in sustaining the genetic basis of agriculture.[lviii]

The primary influence of climate change on ecosystems is expected to be through the rate and magnitude of change in climate means and extremes- climate change is expected to occur at a rapid rate relative to the speed at which ecosystems can adapt and reestablish themselves- and through the direct effects of increased atmospheric CO2 concentrations, which may increase the productivity and efficiency of water use in some plants species. Secondary effects of climate change involve changes in soil characteristics and disturbance regimes (e.g., fires, pests, and diseases), which would favour some species over others and thus change the species composition of ecosystems.[lix] Rough estimates of the effects of a doubling of atmospheric CO2 levels show a major redistribution of earth's vegetation. As much as one third to one half of all plant communities- and the animals that depend on them- might shift in response to changing ecological conditions.[lx]

One of the most significant effects of climate change can be see on corals, that are small animals, mostly living in vast colonies, harvesting nourishment and energy from microscopic algae (plants called zooxanthellae), which inhabit their cells by thousands. The algae are golden brown in colour and combine with other pigments to lend their coral hosts, which largely have transparent tissues, a spectacular hue. When environmentally-stressed, corals lose much of their algae and in this state they appear white and are referred to as "bleached". Victims of global warming, scientists say that 10

per cent of the Earth's coral reefs have been reduced to skeletons, another 30 per cent are in a critical condition and a further 30 are under severe environmental stress. "If he projected levels of climate change are not stopped, the doom may be just 30 years away," warns the IPCC.[lxi]

Preliminary assessments indicate that the Indian Ocean is the most severely impacted region. More than 70 per cent mortality has been observed off the coasts of Kenya, the Maldives, the Andamans and the Lakshwadeep islands. And about 75 per cent of the corals have been reported to be dead in the Seychelles Marine Park System and the Mafia Marine Plant off Tanzania, says Clive Wilkinson of the Global Coral Reef Monitoring network (GCRMN), Townsville, Australia. Scientists believe that global warming could have induced such extensive bleaching simultaneously throughout the disparate reef regions of the world. A study was conducted by Rafe Pomerance, deputy assistant secretary of the state for environment, and his team members, which concluded that record ocean temperatures caused the largest die-off of corals in recorded history and catalogued coral decline in 60 countries. Last year's temperatures in the Indian Ocean, for instance, were about 2°C higher than the normal, enough to cause the bleaching of the corals. According to the Global Coral Reef Alliance (GCRA), every known mass bleaching occurred when temperatures were just 1°C higher than normal during the warmest summer months.[lxii]

Climate plays an important role in maintaining the balance among predators and their prey. For example, freshwater fish, reptiles, birds and bats limit the abundance of mosquitoes, some of which carry **malaria**, yellow fever, **dengue fever** and **encephalitis**. Reduction and fragmentation of habitat worldwide is reducing predator populations. Excessive reliance on pesticides can kill "friendly" insects and predators.[lxiii] According to a Florida-based biologist, high CO2 might make the plants grow faster; they could mean bad news for the plant-eating insects. Peter Stiling, a biologist at the University of South Florida in Tampa, USA, has discovered that subtle increases in CO2 can kill leaf-eating moths by reducing the nutritional value of the leaves- their staple diet.[lxiv]

3.4 The way ahead

The issues of climate change are complex. Whereas the impact speculated and predicted are tremendous, the evidence connecting the science of climate change with the corresponding impact has, so far, been weak. All evidences are speculative and, therefore, largely remain circumstantial. Duane Gubler, director of the division of vector-borne infectious diseases at the Centre for Disease Control (CDC) calls the prognostications "gloom and doom" speculations based on "soft data".[lxv] D A Anderson, an epidemiologist with John Hopkins school of Hygiene and Public Health, Baltimore, US, has been quoted as saying that prediction of impacts "is a lot of simplistic thinking which ignores the fact that as climate changes, so does man."[lxvi] Anderson, Gubler and others believe that breakdown in public health rather than climate shifts are to blame for

the recent disease outbreaks and public health measures will be far more important than the climate in future diseases patterns. Researchers behind dire predictions such as Anthony McMichael of the London School of Hygiene and Tropical Medicine, however, are optimistic. “What it (predictions) does is serve notice; we need to be aware that we are tinkering with fundamentals, and there could be a range of consequences for human health”, he has been quoted as saying.[lxvii]

The current controversy had been building for past few years, sine climatologists began agreeing that the planet’s temperature is rising. In 1991, virologist Robert Shope, then director of the Yale Arbovirus Research Unit, pointed out that with rising heat, the *Aedes aegypti* mosquito, which transmits dengue fever and yellow fever, might move northward, while the life cycles of the mosquito and virus might accelerate, which “could lead to epidemics in North America”. In 1992, microbiologist Rita Colwell of the University of Maryland, college Park took the idea further. She suggested that an El Nino warming of the tropical Pacific was at least partially responsible for a 1991 cholera epidemic in Latin America that affected a half-million people and killed nearly 5000. The last step towards turning these speculations into what Gulber calls “gospel” came in 1996, when the IPCC included a chapter, written by a team led by Anthony McMichael, Paul Epstein and Jonathan Patz, in an update of its landmark 1990 assessment, which concluded that “climate change is likely to have wide-ranging and mostly adverse impacts on human health, with significant loss of life.”[lxviii]

This debate on climate change has reached India also and is leading to heated arguments among scientists. India witnessed a severe heat wave in 1998, and experts are divided over whether the heat wave is an alarming global warming signal or a normal phenomenon no different from other heat waves in the past. The heat wave “is a signal to global warming,” said Dr M Lal at Centre for Atmospheric Sciences at the Indian Institute of Technology, New Delhi. However others believe the present heat wave is similar to others that have been witnessed in India in the past. Delhi Meteorological Office Directorate S C Gupta said that heat waves had occurred in India in the past, notably in 1941, 1958, 1973 and 1994. Temperatures are known to soar during that period over India (when heat wave occurred) and what happened last year was nothing unusual, Mr Gupta said. Sharing this view is S K Sinha, Professor Emeritus at Indian Agricultural Research Institute (IARI), who claimed that similar events have taken place in past 50 years.
According to Dr Lal’s estimates, warming over India could be to the extent of 2 to 3 degree celsius by the end of the next century.[lxix]

Allowing climate change to continue means inviting a health holocaust. There is an urgent need to arrest it, leave alone revert it. In terms of future health care, productivity, international trade, tourism, and insurance costs, what can be salvaged now would be enormous. The transition to cleaner and more efficient energy systems may also prove healthy for economies. Economic analysis shows the benefits of adopting energy

efficiency and new technologies. A global energy transition and an international fund to propel it could become the engine of growth in the global economy of the 21st century. What the issue of climate change needs is concerted efforts to eliminate question mark on its impacts. Third World countries, such as India, which have less research and manpower capabilities in climate change must take a fresh look at the issue lest we lose out in the long term.

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