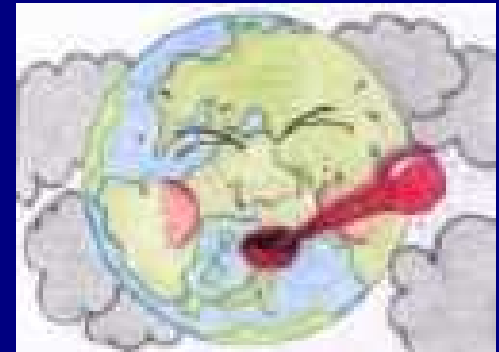


The Effects of Global Warming on WSH in the Developing / Underdeveloped World



Alia Khan
Jennifer Espiritu
Leslie Arney
Tina Lusk



Global Warming

- Global Warming - temperature increases from emissions of CO₂ and other greenhouse gasses.
- IPCC report - results unequivocal that Earth's climate is warming
- IPCC report - very likely that emissions from anthropogenic causes are responsible for most of the observed increases in average global temperatures in 20th century.

IPCC 2007



World-wide Burden of Disease

- WHO estimates that climate changes since 1970's could have led to over 150,000 deaths annually and 5 million DALYs each year



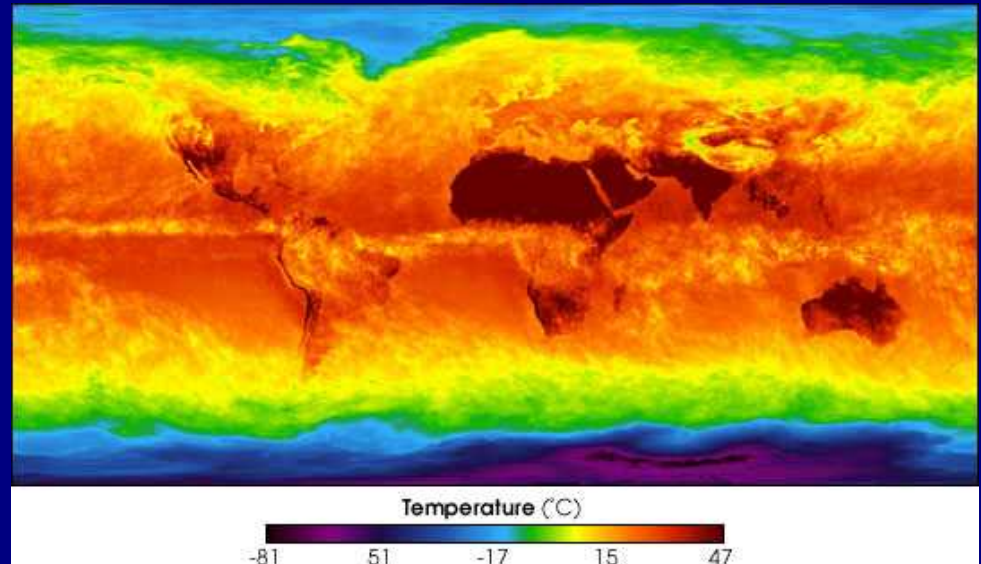
Patz and Olson ,
2006

Burden of Disease in the Developing / Underdeveloped World

- WHO's assessment furthermore revealed that the poorer regions of the world are most vulnerable.

Impacts of Global Warming

- Extreme High Temperature and its effects on Public Health:
 - Food/agriculture
 - Water Resources
 - Sanitation
 - Heat Waves



The Atmospheric Infrared Sounder (AIRS) instrument aboard NASA's [Aqua](#) satellite senses temperature using infrared wavelengths. *April 2003*



State of the Agricultural Sector

- According to the USDA, food security has improved globally – lead to decline in total # of people w/o access to adequate food
- ↓ real price of food grains - greatly improved the food security of the majority of the world's poor, who spend a large share of their incomes on food grains
- Global number, however, masks variation in food security among regions, countries, and social groups that are vulnerable because of low incomes or a lack of access to food

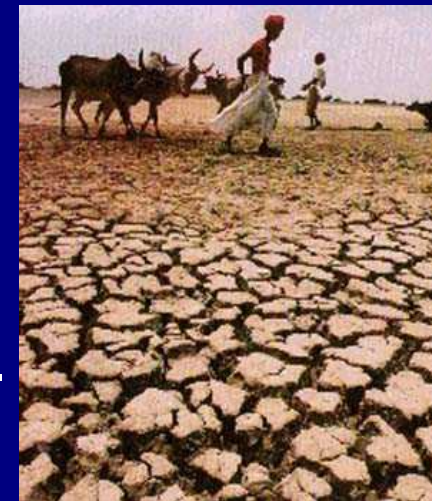
Agriculture – Direct Effects of ↑ CO₂ on Food

- Rice Grain
 - Increase firmness
 - Decrease iron and zinc levels of rice
 - Combined ↑ temp and CO₂ lowers protein content
- Wheat
 - reduces the protein content of grain and flour by 9-13%

Agriculture – World Food Prospects

- Optimistic
 - Population growth expected to decline in 21st century
 - Evidence suggests that agricultural productivity potential is likely to continue to increase
- Not so optimistic
 - Evidence that the Asian rice monoculture may be reaching productivity limits because of adverse impacts on soils and water
 - Arguments that downward trends in food prices and other areas could have been misinterpreted

Drought



- The health impacts of drought on populations occur primarily via impacts on food production.
- Famine often occurs when a preexisting situation of malnutrition worsens. The health consequences of drought include diseases resulting from malnutrition.
- In times of shortage, water is used for cooking rather than hygiene. In particular, this increases the risk of diarrheal diseases (as a result of fecal contamination) and water-washed diseases (e.g., trachoma, scabies).
- Outbreaks of malaria can occur during droughts as a result of changes in vector breeding sites (Bouma and van der Kaay, 1996). Malnutrition also increases susceptibility to infection.

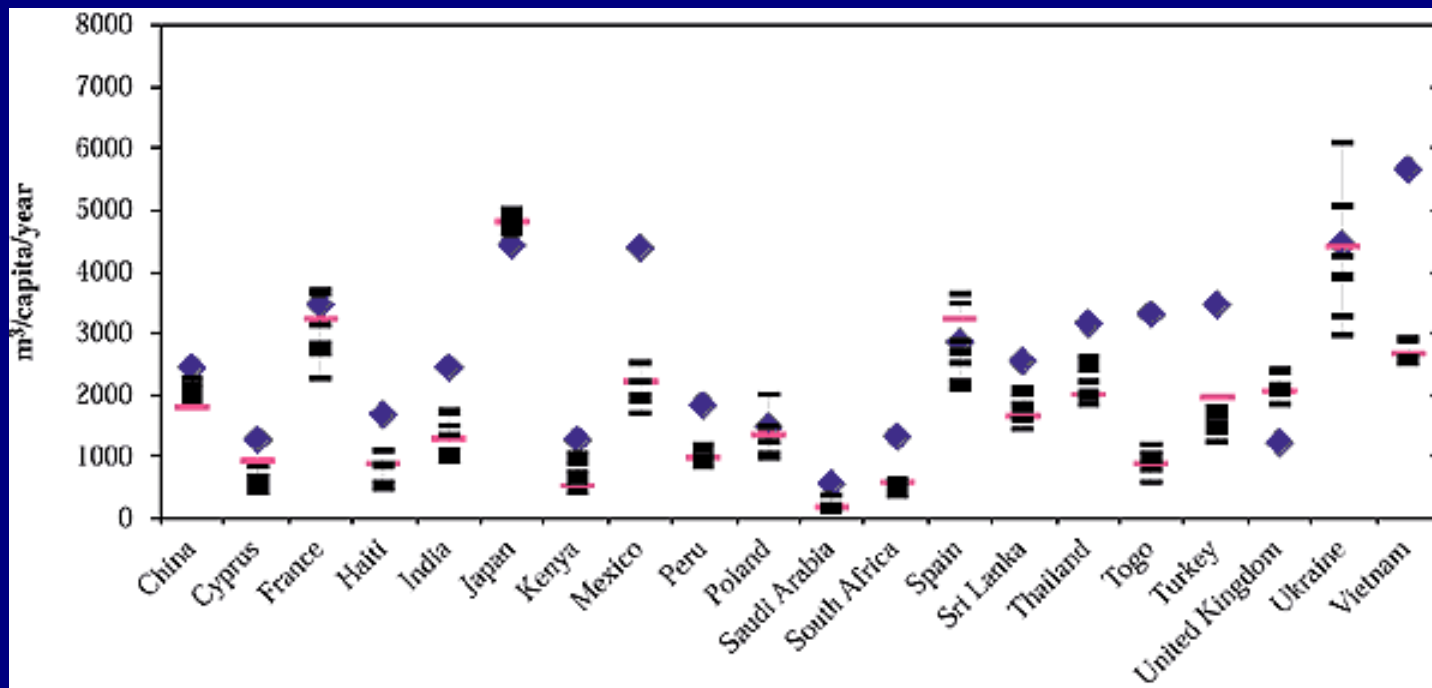
Lack of Water

- Several indicators of water resource stress
 - Amount of water available per person
 - Ratio of water drawn to potential water available
 - Withdrawals greater than 20% of total renewable resources, water stress limits development
 - Withdrawals of 40% or more represents high stress
 - Country has less than 1,700 m³ yr⁻¹ of water per capita
- But indicators also depend on how water is managed

Water Scarcity Over Time

National water resources per capita (m^3 yr $^{-1}$), in 1990 and 2050 under several climate change scenarios, for some countries (Arnell, 2000).

Blue diamonds represent **1990**; long **pink bars** **2050 with no climate change**; and short **black bars** **2050 under different climate change scenarios**.



Heat Waves

- ↑ in the frequency and intensity of heat waves
- Warmer summers and milder winters
- Humidity
- Much bigger health impact in cities than in surrounding suburban and rural areas
 - Urban areas typically experience higher—and nocturnally sustained—temperatures because of the "heat island" effect
 - Air pollution also is typically higher in urban areas, and elevated pollution levels often accompany heat waves



Heat Waves - Mortality

- Excess summer mortality attributable to climate change, assuming acclimatization, was estimated to be 500-1,000 for New York and 100-250 for Detroit by 2050
 - Medium level of certainty assigned to this result
- Mortality from thermal stress in developing country cities may be significant
 - Populations in developing countries (e.g., in Mexico City, New Delhi, Jakarta) may be especially vulnerable because they lack the resources to adapt to heat waves.
 - But, most research refers to developed countries; there has been relatively little research in other populations.

Does climate variability effect human health vulnerability?



Flooding

- Over the next 100 years flooding is predicted to increase in frequency and intensity, especially in low lying coastal areas, and zones those that experience high rainfall.
- Temporary/Permanent Flooding in areas at or below sea level
- Flood risks due to climate change have environmental, technical, and social factors which make determining specific locations at risk difficult.



Direct vs. Indirect

- Direct injury
 - During storm
- Indirect
 - After storm
 - -returning home.
 - Cleaning up debris.
 - Post traumatic stress
 - Property loss and social disruption could cause the risk of mental health problems, such as depression.



Impacts of flooding

- Decrease potable water supply.
- Disrupt sewage lines, releasing microbes into drinking water sources.
- Possible contamination of storm-water out-flows could carry diseases into basements and nearby rivers affecting the health of residents and river users.
- Potential increase of cryptosporidium and campylobacter levels in water.
 - Microparasites which cause diarrheal diseases



AP/St. Petersburg Times

Impacts of flooding cont...



- Immediate effects:
 - Drowning or being swept against hard objects.
- Medium effects:
 - Increase in respiratory diseases due to overcrowded shelters.
 - Increase in communicable/diarrheal diseases due to ingestion of contaminated water
 - Hepatitis A, cholera
 - Other fecal-oral transmission
 - Infection due to helminthes transmission in soil
 - Vector borne disease
 - Rodent Borne disease
- Long term effects:
 - Mental illness, decreased economic and sanitation conditions.

- Coping mechanisms apply at all levels of the hazard management cycle:
 - Mitigation, preparedness, emergency response and recovery.
 - These emergency response systems are generally less developed in developing countries.
 - Lack the resources/funds to develop effective systems.
- Health related management includes:
 - Action in the home and community
 - Storing water above flood-level to avoid contamination.
 - Health and hygiene education
 - How to effectively ration a limited supply of water without decreasing sanitary standards.
 - Warning and evacuation
 - Educating the community on response plans.
 - Disease surveillance and control
 - Health-care provision
 - Protection of health infrastructure
 - Water sanitation protection.

How are we exacerbating the problem?

- Upland forests can soak up a lot of water.
 - Deforestation due to development.
 - increasing hazardous flood risks to homes and people.
- Wetlands can also soak up a lot of moisture.
 - Many are drained to make room for development.
 - Again increase in flood risks.
- The Water Page- http://www.africanwater.org/climatech_fact_sheet13.htm



- The speed and onset of flood waters is a large factor in determining the number of immediate flood-related deaths.
 - Generally weak data on non-drowning (non-immediate) flood related deaths.
 - Infectious disease outbreaks often follow floods, varying in magnitude and morbidity.
 - Evidence from data in India and Bangladesh that rates of diarrheal disease increase after flooding.
 - Due to contamination of potable water.
 - Decrease in availability of clean water, therefore less is used for hygiene/sanitation-> increase spread of disease.

Precipitation

- **Changing precipitation patterns will affect how much water can be captured.**
 - Several models suggest that downpours will become more intense. This would increase floods and runoff while reducing the ability of water to infiltrate the soil. Changes in seasonal patterns may affect the regional distribution of both ground and surface water supplies.

UNEP- http://www.africanwater.org/climatech_fact_sheet13.htm

Glacial Melting

- Glacial melting may lead to flooding, followed by droughts in coming decades.





- The Himalayas contain the largest store of water outside the polar ice caps and feed 7 major Asian rivers.

- The glaciers, which regulate the water supply to the Ganges, Indus, Brahmaputra, Mekong, Thanlwin, Yangtze and Yellow rivers are believed to be retreating at a rate of about 10-15m (33-49ft) each year.
- Hundreds of millions of people throughout China and the Indian subcontinent - most of whom live far from the Himalayas - rely on water supplied from these rivers.



- **Andes Mountains, Peru -- Glacial retreat accelerates seven-fold**
 - The edge of the Qori Kalis glacier was retreating 13 feet (4.0 m) annually between 1963 and 1978. By 1995, the rate had stepped up to 99 feet (30.1 m) per year.
- **Venezuela - Disappearing glaciers.**
 - Of six glaciers in the Venezuelan Andes in 1972, only 2 remain.
 - scientists predict that these will be gone within the next 10 years.Glaciers in the mountains of Colombia, Ecuador, and Peru show similar rapid rates of retreat. Temperature records in other regions of the Andes show a significant warming of about 0.6 F (0.33 C) per decade since the mid-1970s.
- **Andes Mountains, Columbia -- Disease-carrying mosquitoes spreading.**
 - *Aedes aegypti* mosquitoes that can carry dengue and yellow fever viruses were previously limited to 3,300 feet (1,006 m) but recently appeared at 7,200 feet (2,195 m).

Rising Sea Levels

- Global sea levels have risen 10-25cm in the last 100 years.
 - Inundation of coastal areas- increased cost to protect those areas.
 - Migration of disease carrying vectors further inland.
 - Increased competition for land.
 - -> increased competition for jobs.
 - Increased competition for water resources.
 - -> future political conflict
 - Western U.S.
 - Loss of habitat and species.
 - Increased contact between animals/humans as ecological niches are destroyed by flooding/rising sea levels.

Potential impact of sea-level rise on Bangladesh



Today

Total population: 112 Million

Total land area: 134,000 km²



1.5 m - Impact

Total population affected: 17 Million (15%)

Total land area affected: 22,000 km² (16%)

GRID
Arendal
UNEP

Source : UNEP/GRID Geneva; University of Dhaka; JRO Munich; The World Bank; World Resources Institute, Washington D.C.

1.5 meter rise in sea level could displace over 17 million people in Bangladesh.

UN- Environment Program: <http://www.grida.no/climate/vital/33.htm>

Effects of Climate Change on Infectious Disease

Key Concepts

- Climate is a key factor in the geographical distribution and range of many infectious diseases
- Weather affects the characteristics of disease outbreaks (timing and intensity)

Diseases of Interest

Vector-borne diseases: Malaria and Dengue

- endemic to more than 100 countries
- represent the greatest burden to human health among all vector-borne diseases.
- Others: Yellow Fever, West Nile Virus, encephalitis

Water-related diseases: Cholera and Schistosomiasis

- Others: Cryptosporidium, Giardia

Vector-borne diseases

- Changes in temperature affect the breeding, maturation, and survival of vectors which lead to changes in their geographic distribution
- Increases in the average temperature and levels of precipitation has already facilitated spread
- Incidence also depends on relationships among hosts, pathogens, and vectors

(Huei-ting Tsai, 2005)

Malaria

Pathogen: Plasmodium falciparum, P. vivax, P. ovale, P. malariae

Vector: Anopheles mosquito

Hosts: female anopheles mosquito and humans

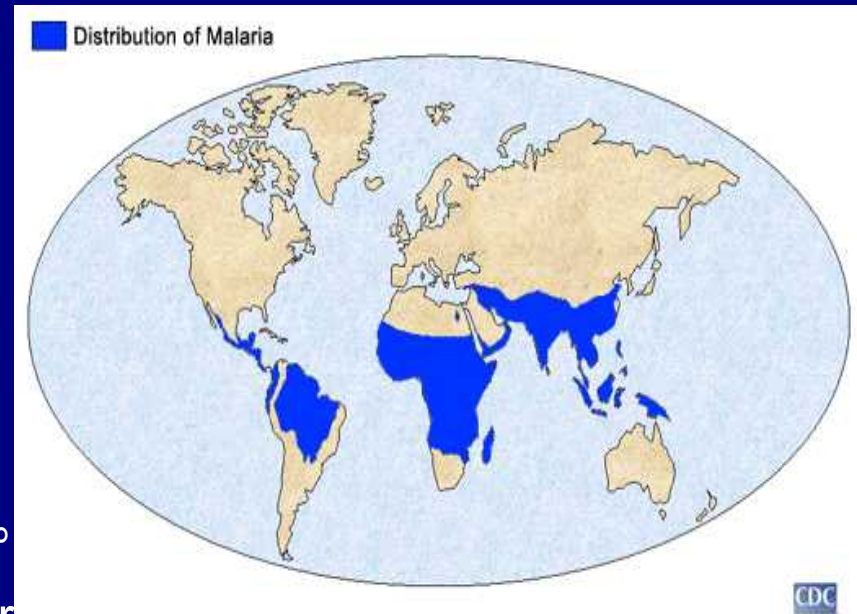
Breeding sites: water

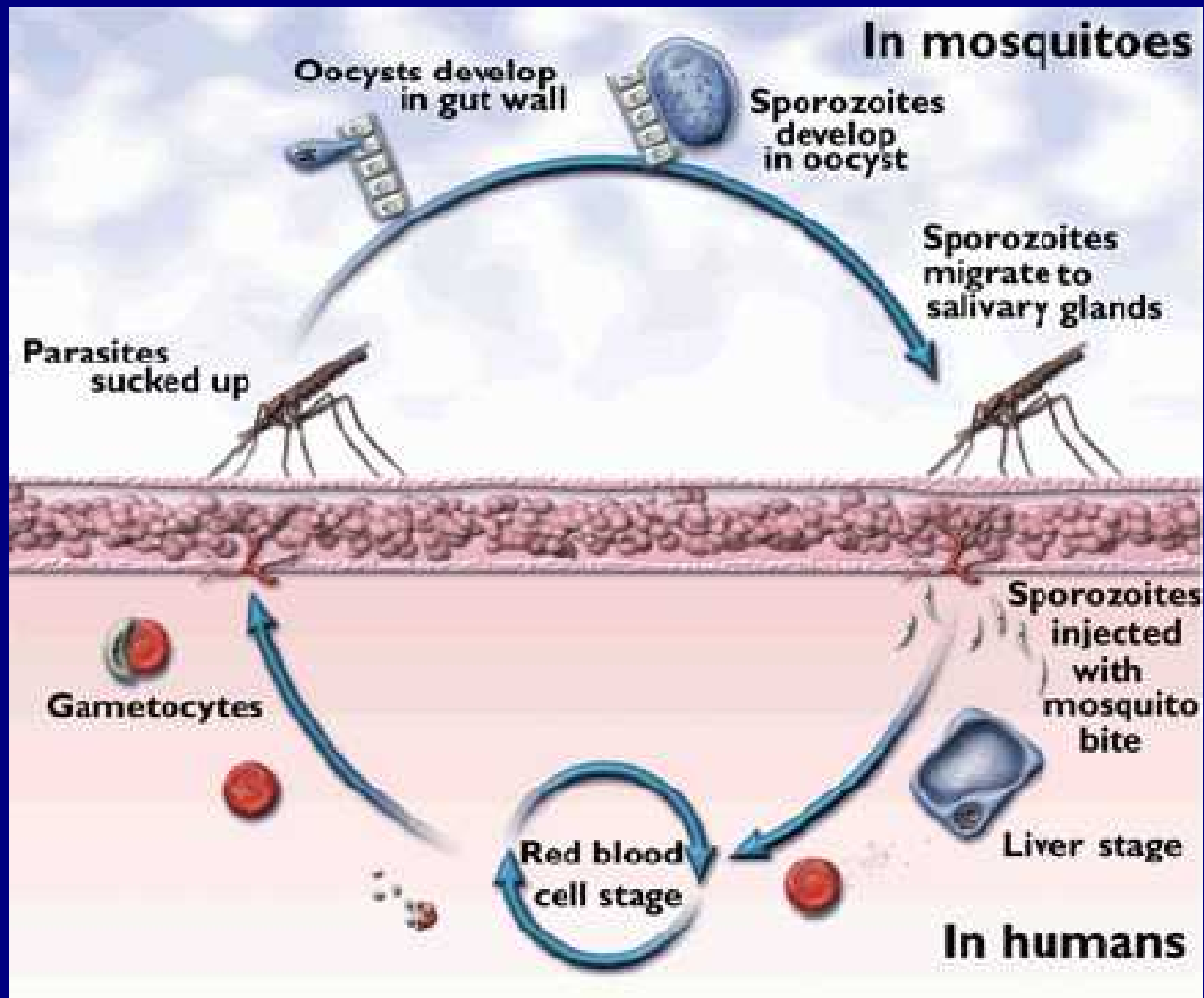


- Climate determines prevalence of disease, geographical distribution, and seasonality of transmission

Geographic Distribution

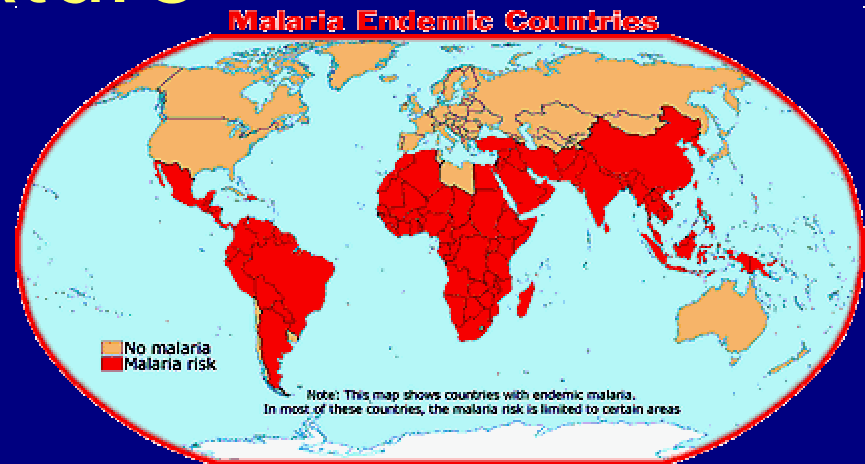
- Location:
 - Tropical and sub-tropical areas
 - Sub-Saharan Africa, South and Southeast Asia
- Temperature: key determinant
 - Effective malaria transmission $>20^\circ$
 - *P. falciparum* cannot complete its gametocyte development
- Rainfall:
 - Increases in average precipitation and/or flooding produces standing water \rightarrow creates additional breeding sites





Effect of Temperature

- mosquito's rate of reproduction
 - increased density of vector
 - increased biting activity
 - increased transmission
- rate at which parasites mature
 - shorter extrinsic incubation period
 - increased transmission



At 20 ° C, *P. falciparum* take 26 days to incubate

At 25 ° C, 13 days.

Dengue Virus

Pathogen: Flavivirus

Vector: *Aedes aegypti* mosquito



- Location:
 - Year-round transmission in tropical, sub-tropical areas
 - Seasonal peak during months of high rainfall and humidity
- Increased temperature:
 - Mosquito larvae develop faster
 - Faster maturation → more adults capable of transmission
 - Viruses have shorter extrinsic incubation periods
 - virus can cycle more rapidly in the mosquito
 - increase speed of epidemic spread

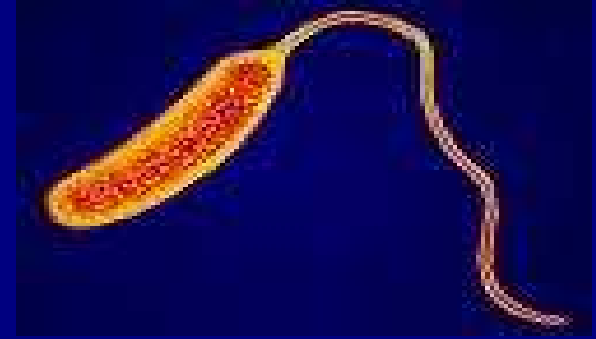
Water-related Diseases

- Extreme weather can have a great impact on water sanitation and hygiene
- *Droughts*: Water scarcity often results in the use of poorer quality sources of water, decrease efficiency of sewage systems
- *Floods*: Excessive precipitation can result in contamination of drinking water sources caused by destruction of sewage treatment plants
 - Ex) Heavy rainfall events in the UK and United States have triggered outbreaks of cryptosporidiosis and giardia
 - Ex) 1997-1998 El Niño, excessive flooding caused cholera epidemics in Djibouti, Somalia, Kenya, Tanzania, and Mozambique (WHO, 1998b)

Cholera

Bacteria: *Vibrio Cholerae*

Potential reservoir: copepod zooplankton,
found in some shellfish



- Temperature: dictates seasonality and geographic distribution
 - Tropical areas – year round cases reported
 - Temperate areas – cases only reported in warmest season

also may be linked to...

- Seasonality of plankton blooms
 - Caused by warming of sea surface temperature
(Colwell, 1996)

Schistosomiasis



- Pathogen: trematode Schistosoma
 - Host: water snails
 - Prevalent in Irrigation systems: hot climates where snail populations can survive and parasite can find human parasite carriers
 - Effect of climate change:
 - water shortages → more irrigation systems and increases in host snail populations
 - trematode egg production increases at high temps
- (Schorr *et al.*, 1984)

Conclusion

- Regions with greatest burden of climate-sensitive diseases have lowest capacity to adapt
 - Effects reflected in food and water resources, and sanitation.
 - Infrastructures already operating at capacity

Conclusion

- Disease burden composed of usual players (respiratory infections, vector borne diseases, diarrhea) coupled with worsening state of health due to (even worse than baseline) malnutrition and collapse of (already tenuous) infrastructures

Conclusion

- Immediate effects in the developing / under developed world will have longer reaching consequences over time



Sources:

- International Panel on Climate Change, 2007 Summary, last updated 06 April 2007, last accessed 23 April 2007 at www.ipcc.ch.
- International Panel on Climate Change, 2001 Report - <http://www.grida.no/climate/ipcc>.
- Few, Roger. "Floods, Health, and Climate Change: a Strategic Review". Tyndall Centre for Climate Change Research. 2004 November; 4-10.
- Patz JA, Olson SH. "Climate change and health: global to local influences on disease risk." *Ann Trop Med Parasitol*. 2006 Jul-Sep;100(5-6):535-49. Review.
- Rose, Joan B. Climate Variability and Change in the United States: Potential Impacts on Water- and Foodborne Diseases Caused by Microbiologic Agents.
- Schiermeier Q. "The costs of global warming." *Nature*. 2006 Jan 26;439(7075):374-5
- Shope, Robert. Global Climate Change and Infectious Diseases. *Environmental Health Perspectives* Vol. 96, pp. 171-174, 1991.
- Smith, HV. Sporulation of *Cyclospora* sp. Oocysts. *Appl. Environ. Microbiol.*, Apr 1997, 1631-1632, Vol 63, No. 4. Copyright © 1997, American Society for Microbiology.
- Water Policy International Limited, "The Water Page" 2000/1. Last accessed 23 April 2007 at http://www.africanwater.org/climatech_fact_sheet13.htm.