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Water quality, quantity and climate change

The world-wide challenges of water quality and quantity related health problems as result of climate change

Pauline Scheelbeek

Part 1

The relationship between water and health

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Introduction

How are water and health related

- Microbiological contamination
  - Bacteria
  - Protozoa
  - Parasites
  - Viruses

  Through human an animal faeces

- Chemical contamination
  - Arsenic
  - Fluoride
  - Salt

  Through chemical use and storage, agriculture, seawater

- Other hazards
  - Primary: hypothermia, drowning, injury
  - Secondary: malnutrition, mental health issues

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Infectious Diseases related to Water

Different types of water associated infectious diseases:

- Waterborne diseases:

  Transmission through ingestion of water — such as drinking.

  Some common waterborne diseases include:

  - Caused by bacteria: *Cholera, Leptospirosis, Typhoid fever, Diarrhoea (E coli)*
  - Caused by viruses: Hepatitis A, Hepatitis E
  - Caused by parasites: Giardia, Cryptosporidiosis

- Water washed diseases:

  Transmission due to lack of water / inadequate hygiene.

  Some common water washed diseases include:

  - Trachoma
  - Scabies

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Infectious Diseases related to Water

Different types of water associated infectious diseases:

- Water based diseases:

  Transmission through contact with water (through bathing)

  Some common water based diseases include

  - Schistosomiasis (can lead to serious conditions such as bladder cancer)
  - Guinea worms

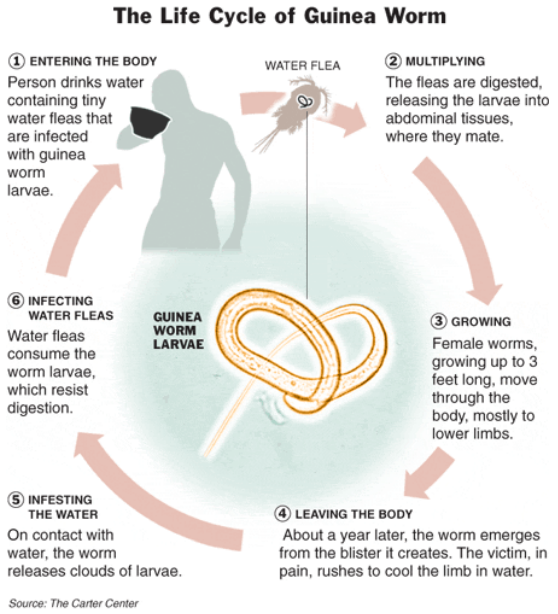
- Water related disease:

  Transmission through vectors proliferating in water reservoirs

  Some common water related diseases include:

  - Malaria
  - Dengue fever
  - Yellow fever

- Other: e.g through contaminated aerosols: legionellosis



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Chronic Diseases related to Water

Different types of water associated chronic diseases:

- Many different diseases can occur as result of chemical contamination, depending on type and concentration of chemicals.

  Some frequently occurring water associated chronic diseases include:

  - Arsenicosis
  - Fluorisis
  - Various types of cancer (hypotheses)
  - Hypertension
  - Preeclampsia (hypothesis)

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Other health issues related to Water

Excess or lack of water:

- Health issues related to excess of water:

  In case of floods, overflowing rivers, etc., health risks could occur, such as:
  - Drowning
  - Hypothermia

- Health issues related to lack of water:

  In case of droughts health risks could occur such as:
  - (Severe) dehydration
  - Malnutrition

- In addition to these health issues, these events could cause mental health issues such as mental distress and suicide

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The numbers

What numbers are we talking about?

Disease	Year	Global Annual Cases	CFR
Cholera	2011	589,854 - 1,200,000	1.30% - 10.00%
Typhoid	2000	21,650,974	5.00%
Hepatitis A	2005	31,000,000	0.10%
Hepatitis E	2005	3,400,000	2.06%
Schistosomiasis	2011	207,000,000	0.01%
Trachoma	2011	84,000,000	0.00%
Malaria	2009	225,000,000	0.35%
Dengue	2005	1,300,000	unknown
Drowning	2012	N.A.	388 000

Source: WHO 2004, 2008 & 2012

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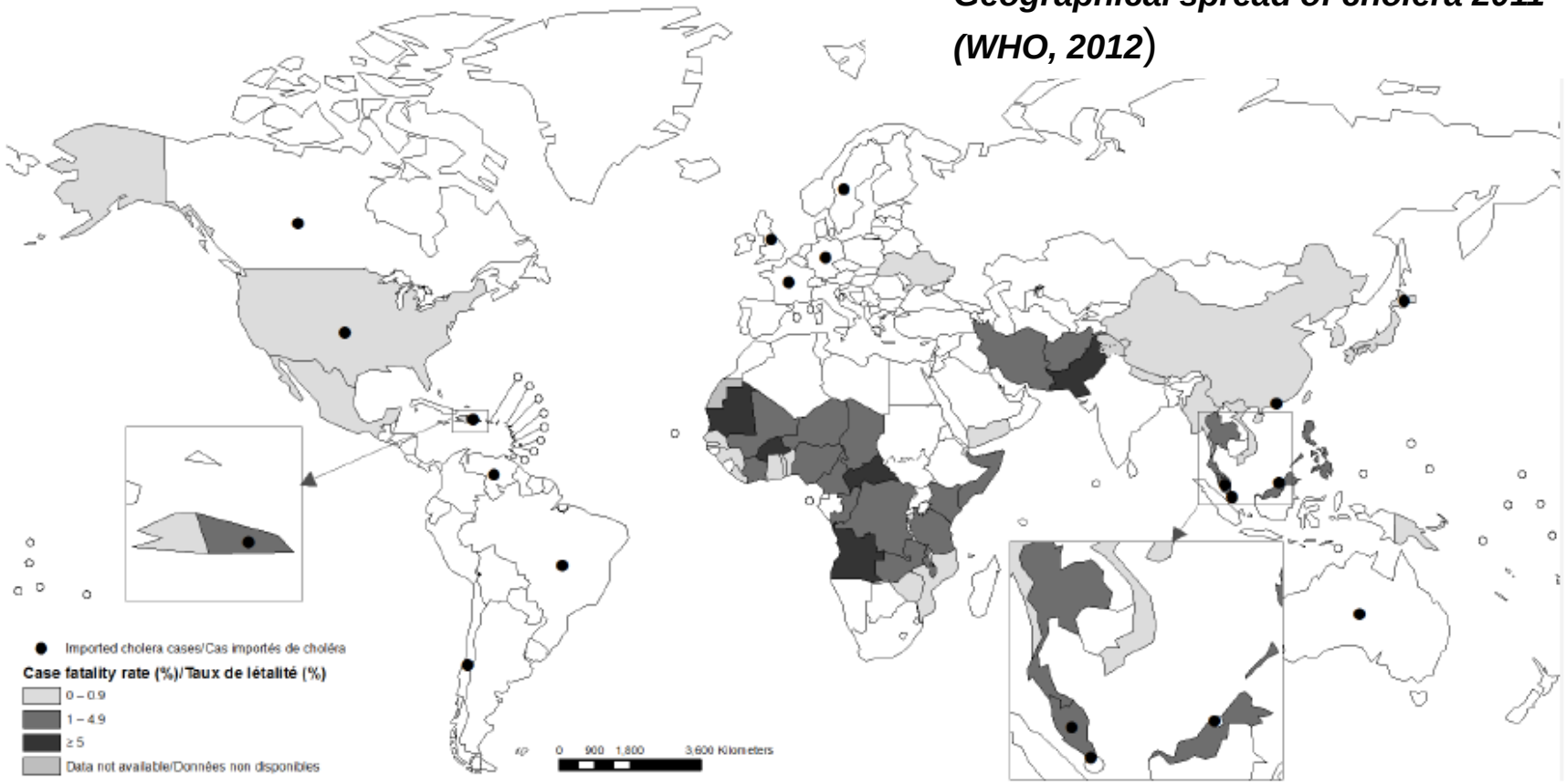
Geographical spread of disease associated with water

Where do we find the greatest burden of disease associated with water?

Geographical spread of cholera 2011 (WHO, 2012)



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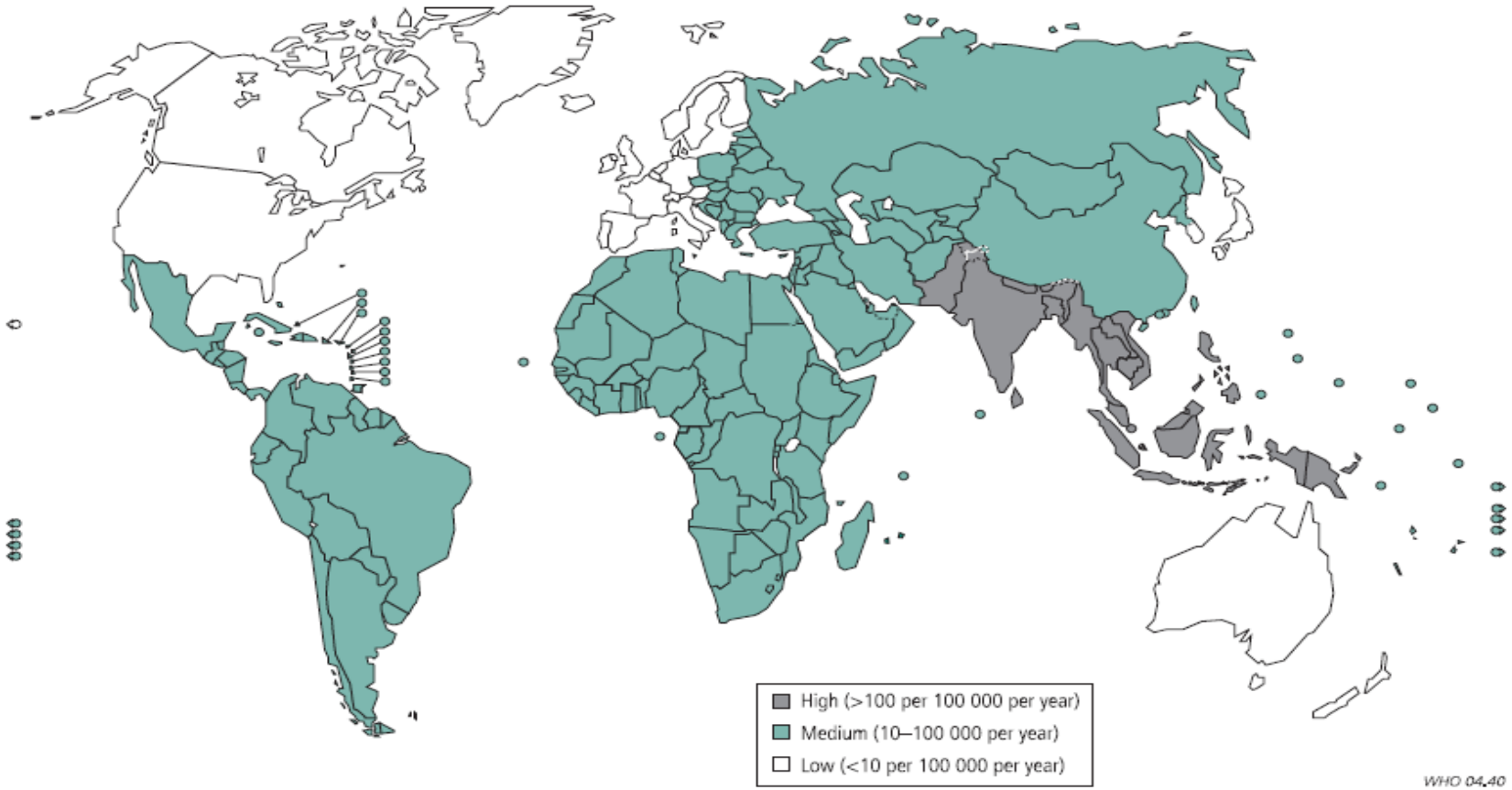
Geographical spread of disease associated with water

Where do we find the greatest burden of disease associated with water?

Geographical spread of typhoid fever



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Geographical spread of disease associated with water

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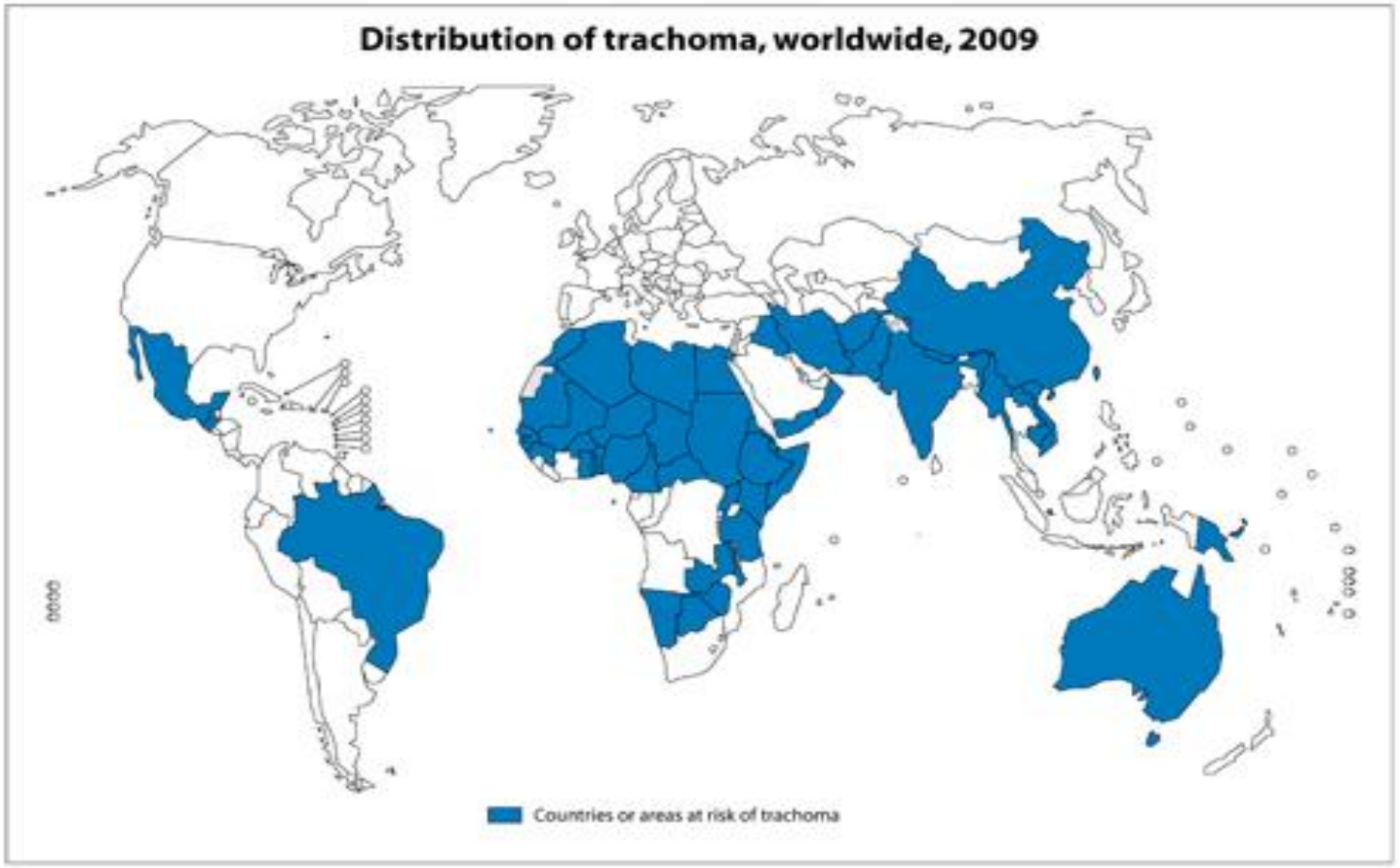

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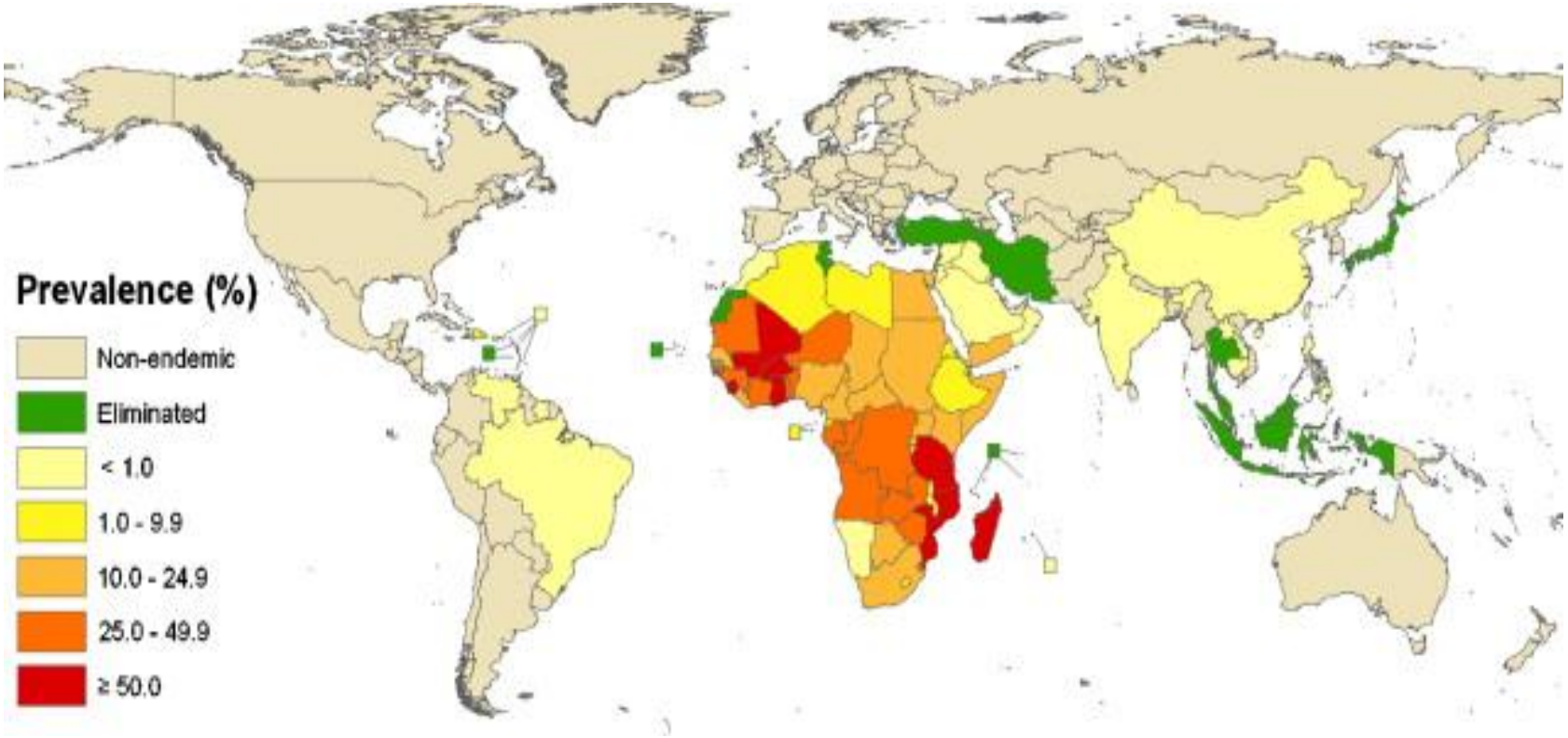
Geographical spread of disease associated with water

Where do we find the greatest burden of disease associated with water?



Global prevalence schistosomiasis, 2011

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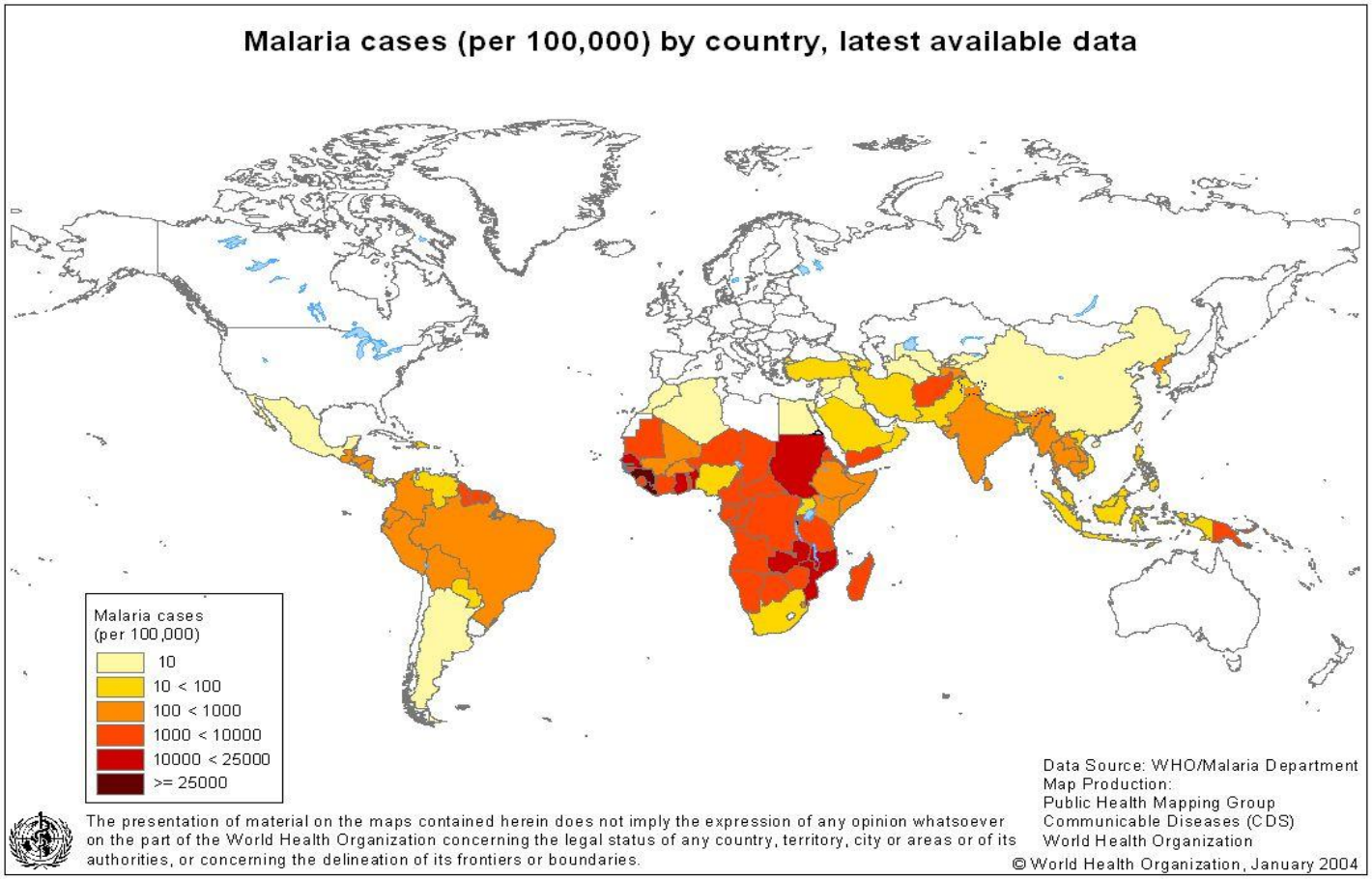
Geographical spread of disease associated with water

Where do we find the greatest burden of disease associated with water?



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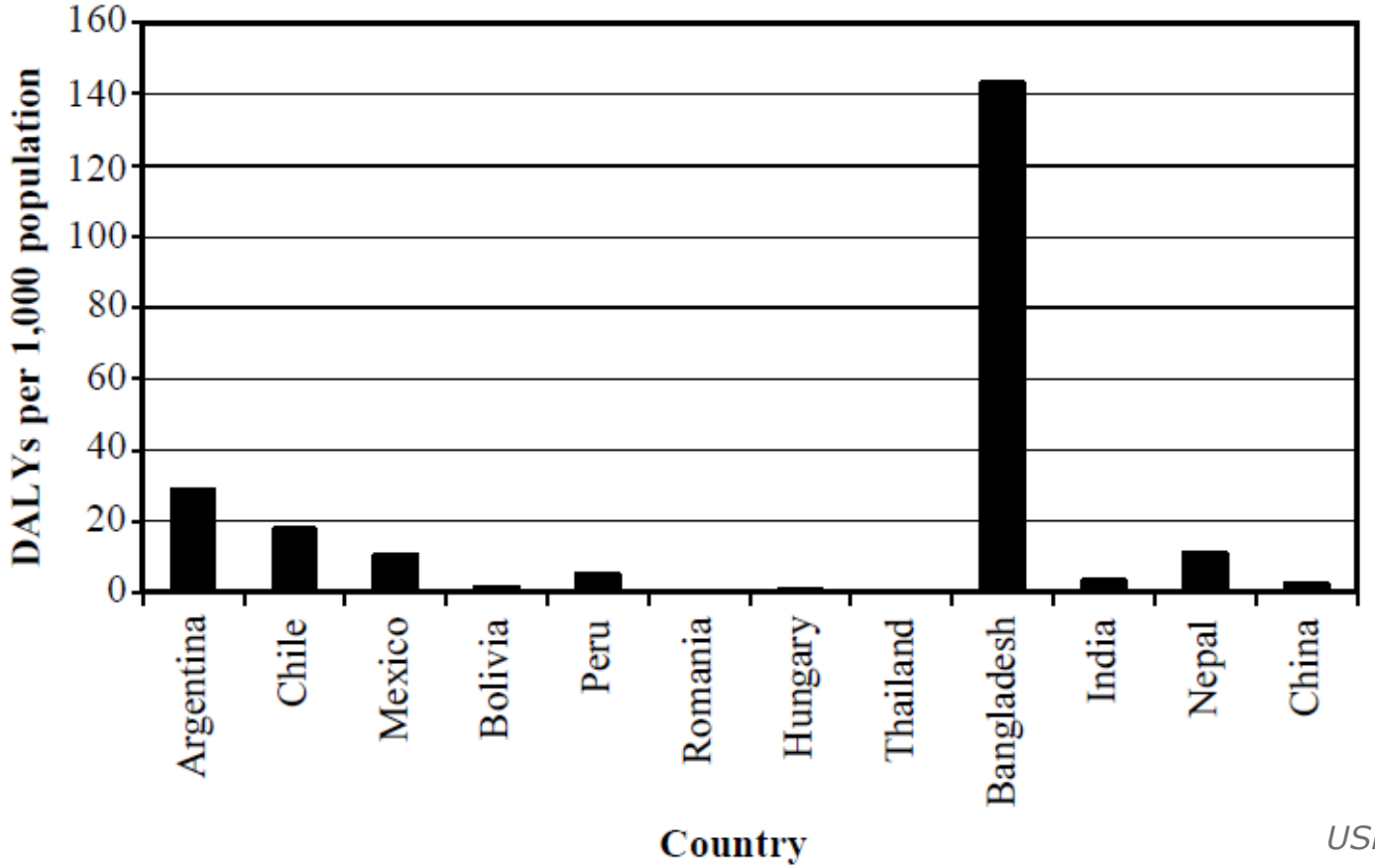
Geographical spread of disease associated with water

Where do we find the greatest burden of disease associated with water?

DALYs attributable to arsenicosis 1999



*USNRC, **1999***

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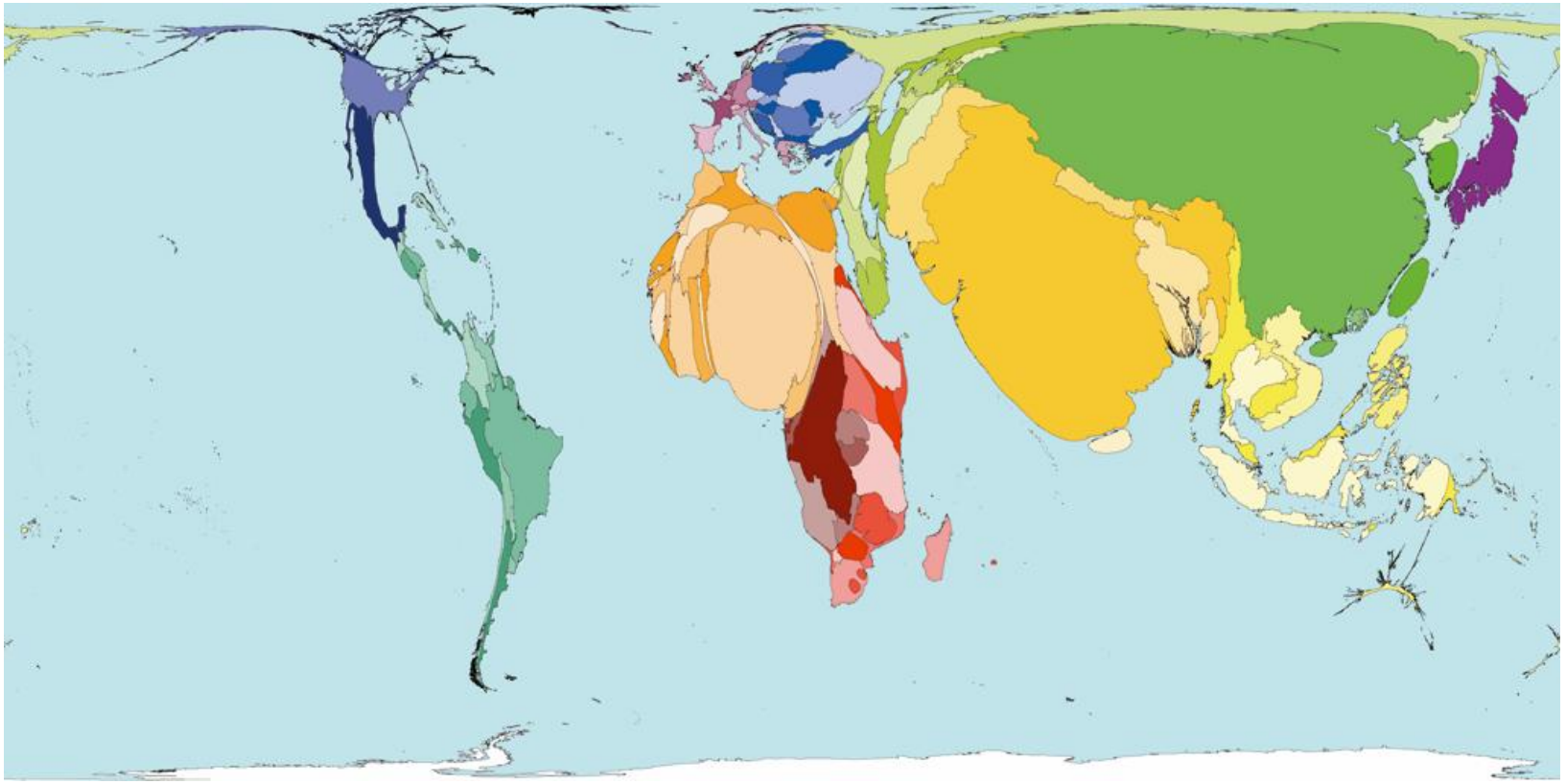
Geographical spread of disease associated with water

Where do we find the greatest burden of disease associated with water?

Global drowning figures (country size proportional to drowning cases)



UNICEF 2012

Part 2

Effect of climate change on water & water associated disease burden

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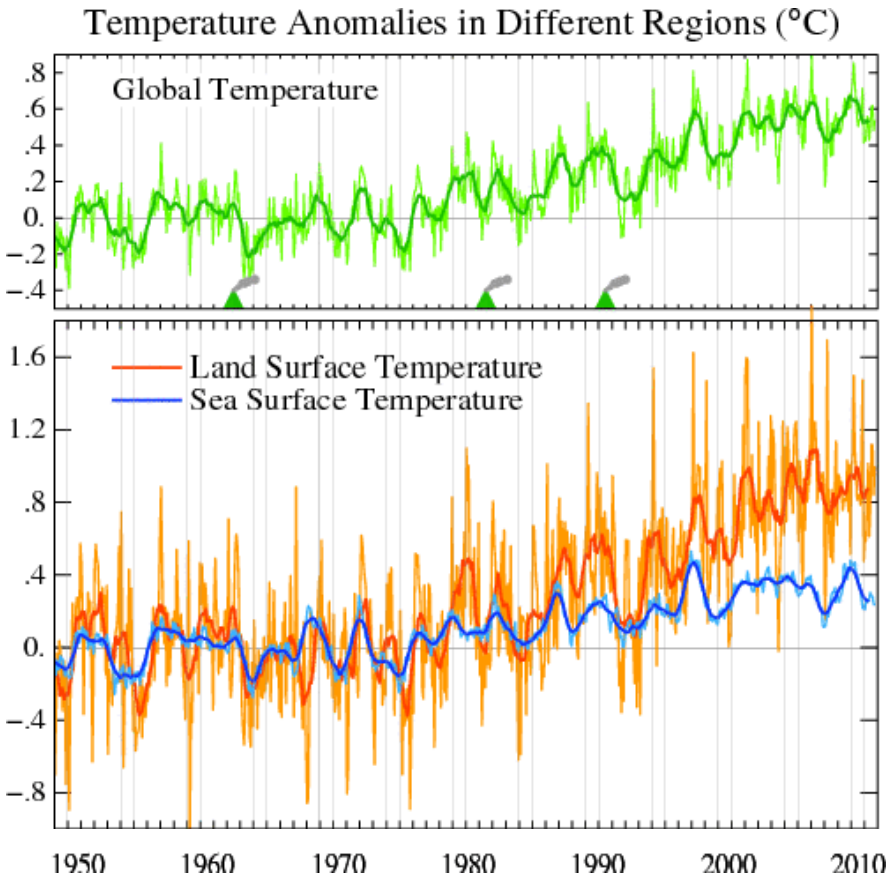
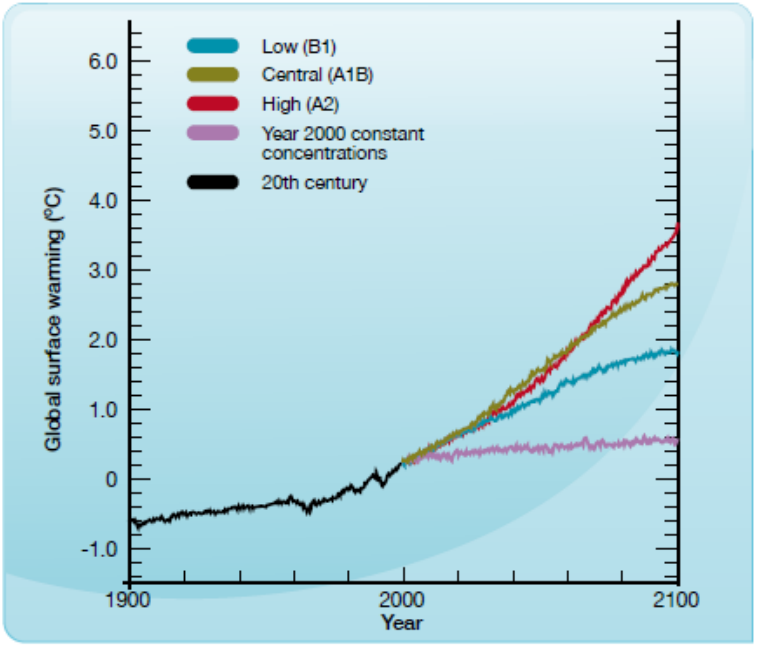
Climate change

What is going to happen?



Predictions of surface temperature till 2100



Source: IPCC (2007)

Source: NOAA National Weather Service Climate Prediction Centre.

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Intergovernmental Panel on Climate Change

Conclusions IPCC technical report:

- Global warming during the last decades has been linked to changes and hazards such as:
  - Increasing atmospheric vapour content
  - Increasing land and water temperatures
  - Changing precipitation patterns: more extreme whether events
  - Melting of ice
  - Rising sea level

- Climate models suggest that precipitations and river run-off will increase in high latitudes and decrease in lower-mid latitude regions

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Effects of climate change on water bodies

The rise in temperature and changing precipitation patterns have an impact on water quality & quantity.

Effects that are expected or already on-going include:

- Water quality
  - Rise of overall water temperature
  - Change of pH & nutrients
  - Change in salinity levels
- Water quantity
  - More frequent floods
  - More frequent droughts
  - Intense rainfall

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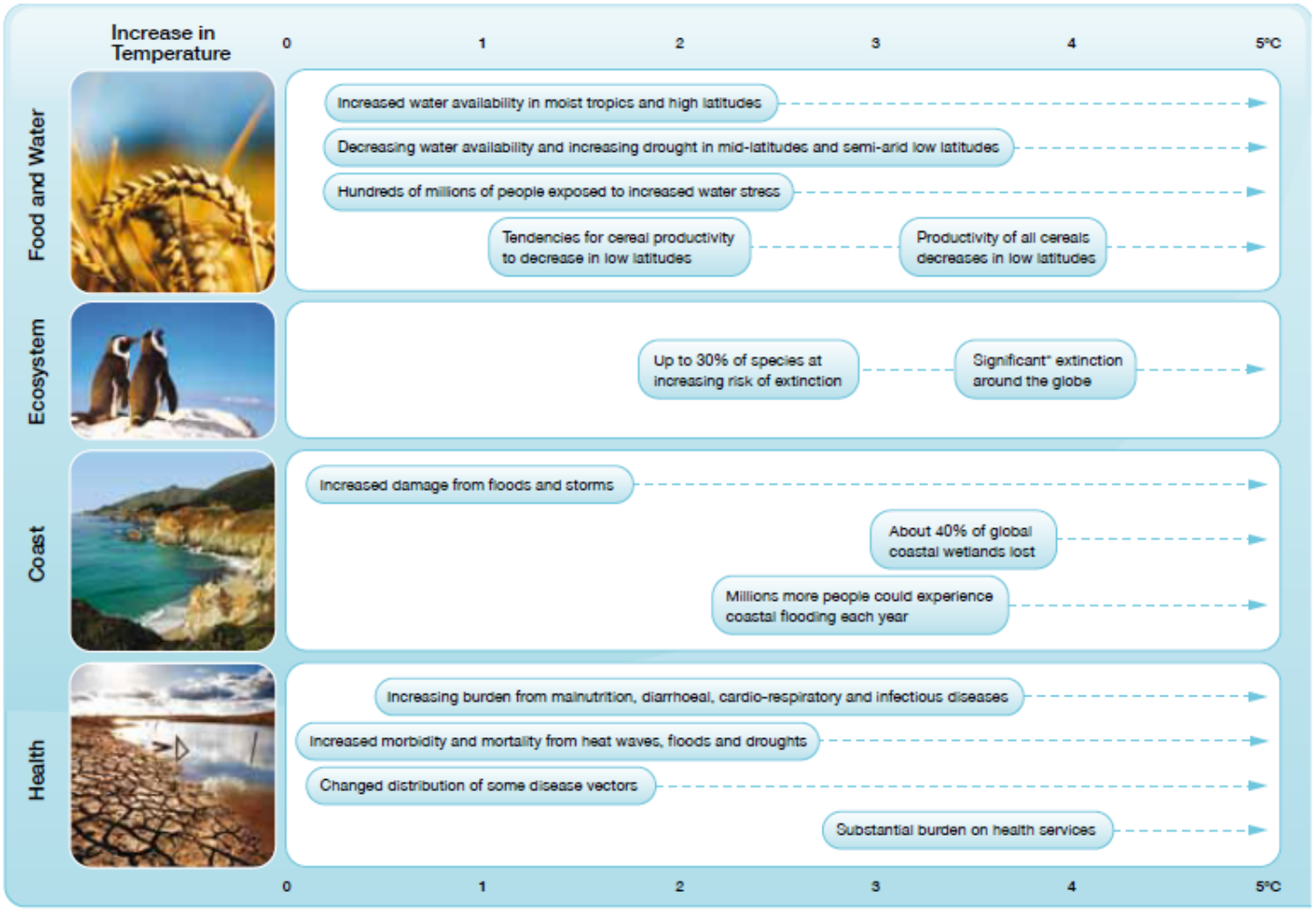
Effect of climate change on water associated disease



* Significant is defined as more than 40%
Source: Adapted from IPCC (2007)

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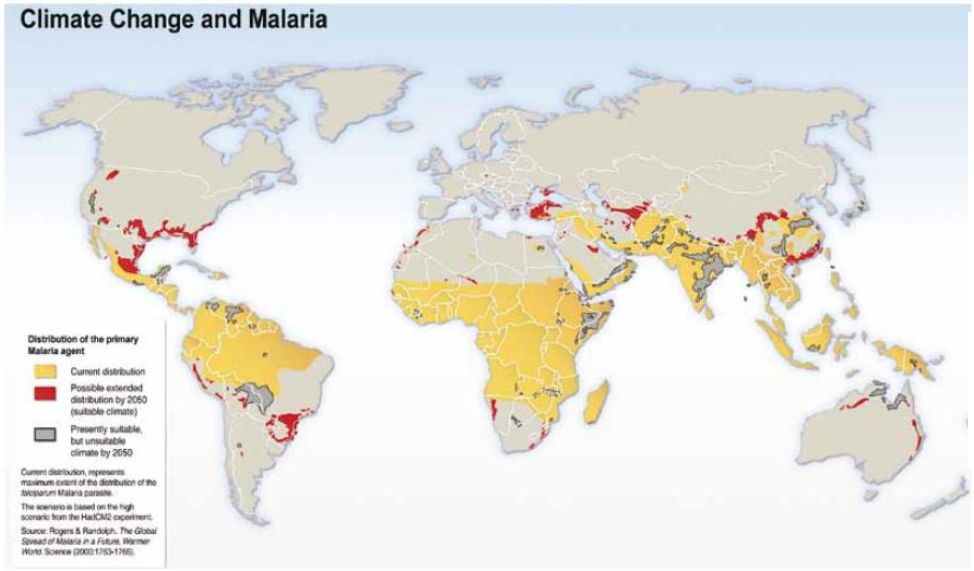
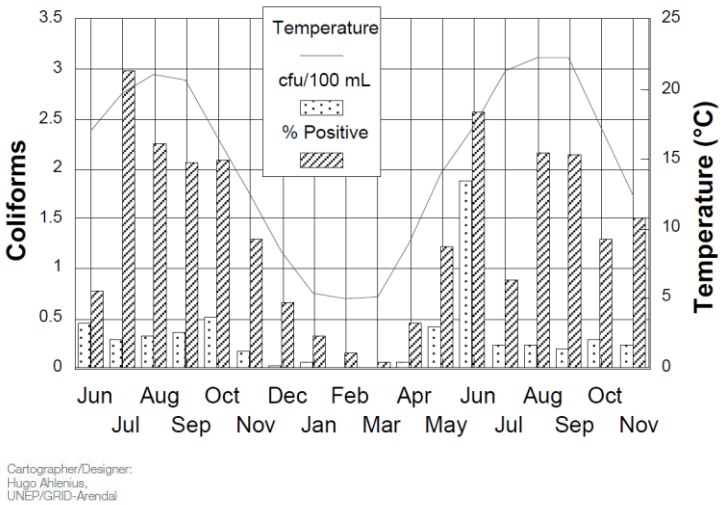
Effect of climate change on water associated disease

Change of water temperature, pH and nutrients

- Increase of water temperature creates:
  - More favourable circumstances for bacteria, viruses and parasites to survive and replicate: more potential for epidemics
  - Water bodies in temperate areas become suitable as breeding places for mosquitoes and flies: possible expansion of the malaria and dengue fever areas





Cartographer/Designer:
Hugo Ahlenius,
UNEP/GRID-Arendal

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Effect of climate change on water associated disease

Change of water temperature, pH and nutrients

- Increase of pH
  - Already moderate changes in pH have potential to cause compositional shifts in pathogens load
  - Depending on the local environmental factors and pathogen distribution

- Increase of nutrients
  - Due to run-off of domestic and agricultural areas
  - Direct effect on growth rate of bacteria
  - Indirect affect through growth of algae: some bacteria adhere to algae and can much longer persist in the environment (e.g. *V. cholerae*)
  - Direct effect on humans e.g. methaemoglobinaemia due to exposure to nitrates (can cause: baby blue syndrome)

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Effect of climate change on water associated disease

Change of salinity levels

A major problem concerning water quality associated with climate change / sea level rise is salinity of drinking water:

- Affect millions of individuals in coastal regions around the world.
- Is expected to increase over time
- IPCC: "*Groundwater, crop soils, and many rivers likely to become increasingly saline from floods, higher tidal waves and storm surges, as a result of climate change impacts*"

- In addition: rapid population growth in (fertile)coastal areas.
- Therefore large pressure on available water resources.

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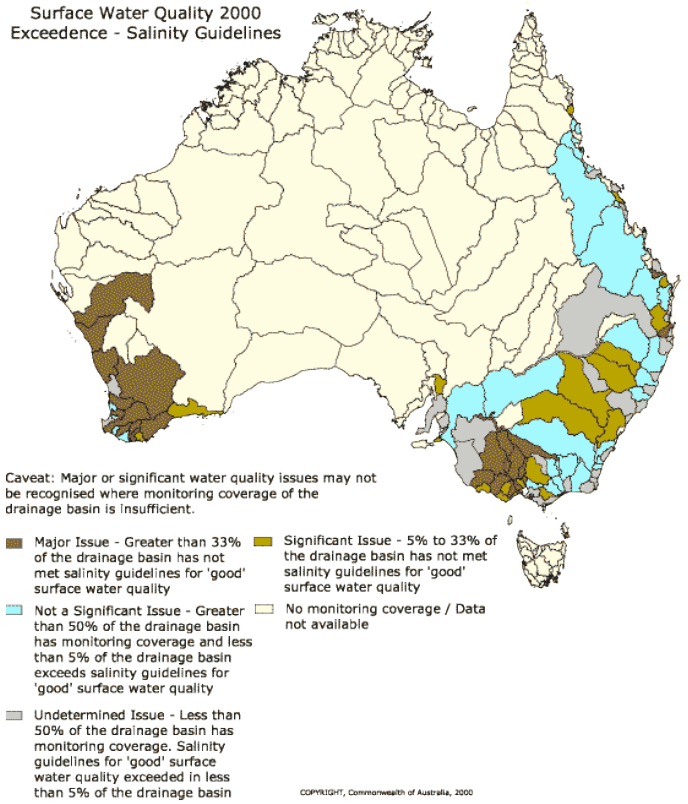
Salt intrusion

The rise in temperature and changing precipitation patterns have an impact on water quality & quantity.

- FAO guideline for sodium levels in drinking water: 0.5 ppt (grams per kilogram of water)
- Salinity of sea water (extremely harmful for humans): 35 ppt
- In Bangladesh: sodium levels up to 13 ppt were measured in sources used for human consumption (second lecture)



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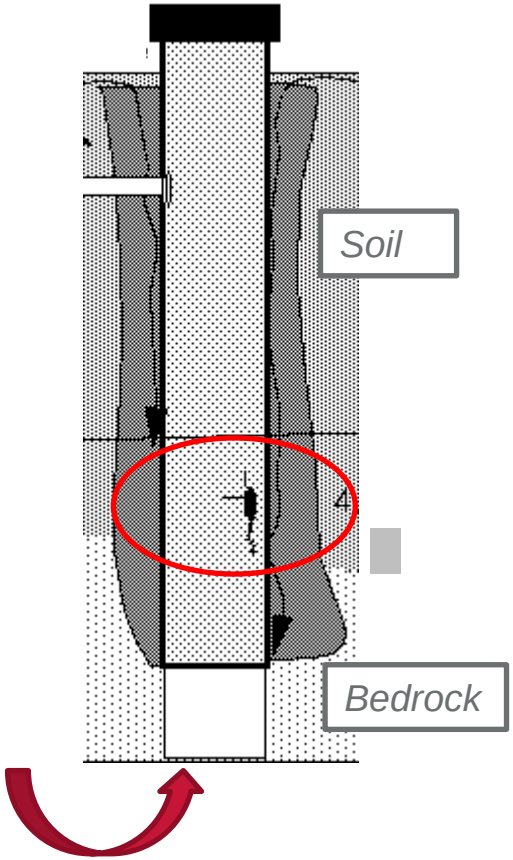
Salt intrusion



How does salt intrude the fresh water sources:

- Open: water just physically flows into the source (e.g. open well, river, pond)
- Protected sources (e.g. deep wells): sea water seeps in if not well constructed
- Ground water contaminated with saline water

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Salt intrusion: health effects

Change of salinity levels

The health effects of increase salt studied by many, but mostly on dietary salt:

- Excessive dietary salt intake: high blood pressure
- High sodium intake: rise in systolic and diastolic BP
- Reducing salt: major effect on BP, preventing cardiovascular mortality
- In pregnant women increased levels of sodium intake may lead to pergnancy related problems

- High BP in developed countries is the major cause of cardiovascular disease, responsible for 62% of strokes and 49% of coronary heart disease
- In sub-Saharan countries: cardiovascular diseases responsible for 12% of all deaths. In Asian countries: 24%

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Effect of climate change on water associated disease

Effect of Floods

- A 40 cm rise in sea level is expected to increase the average annual numbers of people affected by coastal storm surges from less than 50 million at present to nearly 250 million by 2080.

- Floods often associated with outbreaks of infectious diseases:
  - Wells flooded
  - Latrine pits full of water
  - Bacteria no longer concentrated, but everywhere in domestic area
  - Diseased person sheds millions of bacteria

- Increased number of injuries, drowning, electrocution

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Effect of climate change on water associated disease

Outbreaks

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Effect of climate change on water associated disease

Effect of Floods

- Also “outbreaks” due to chemicals that were flushed in domestic areas during floods:
  - Hurricane Mitch (1998) Honduras: Pesticides in drinking water: people reported headaches, tiredness, skin rash, abdominal pain, fever, etc
  - Tropical Storm and flood Alberto (1994) USA: Agricultural chemicals (fertilisers etc): Decreased appetite, fever, headache etc
  - Flood of mine (1950) Japan: Cadmium, lead and zinc: Leading to “Itai Itai disease” (osteomalacia)

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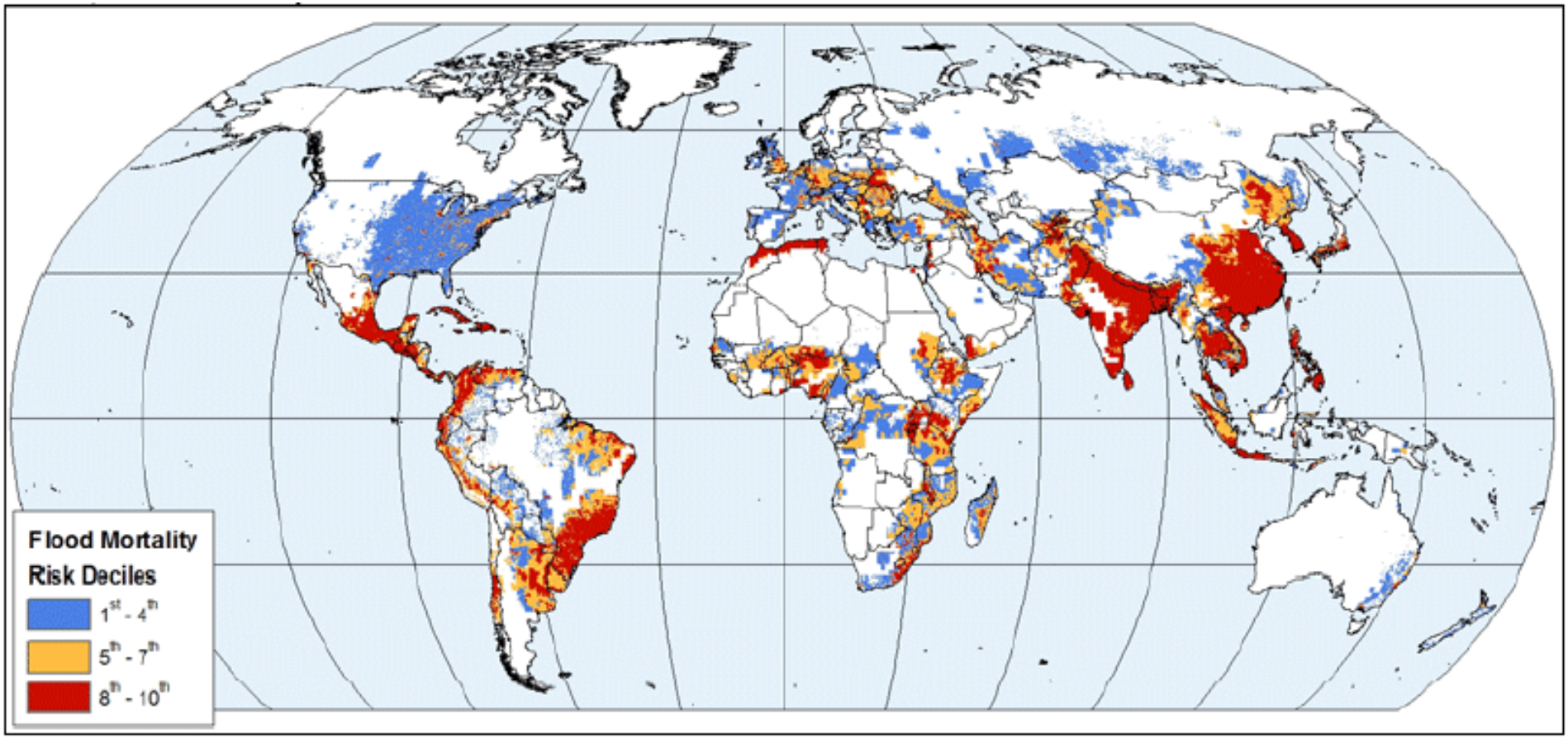
Effect of climate change on water associated disease

Global Distribution of Flood-Related Mortality Risk



Centre for Hazards and Risk Research at Columbia University, 2005. Natural Disaster Hotspots: A Global Risk Analysis

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Effect of climate change on water associated disease

Effect of Droughts

- Over the past 50 years, severe drought has increased by around 1 - 3 % around the globe.
- By 2050 it is anticipated to increase to 12% if global temperatures rise by 2°C above pre-industrial values.
- Droughts lead to
  - Outbreaks of infectious diseases (due to lack of water) & (severe) dehydration
  - Poor harvests: pressure on agricultural fields
  - Hunger, malnutrition

- UN World Food Programme: number of food emergencies (famines) every year has increased from an average of 15 during the 1980s to more than 30 currently. (WFP, 2011)

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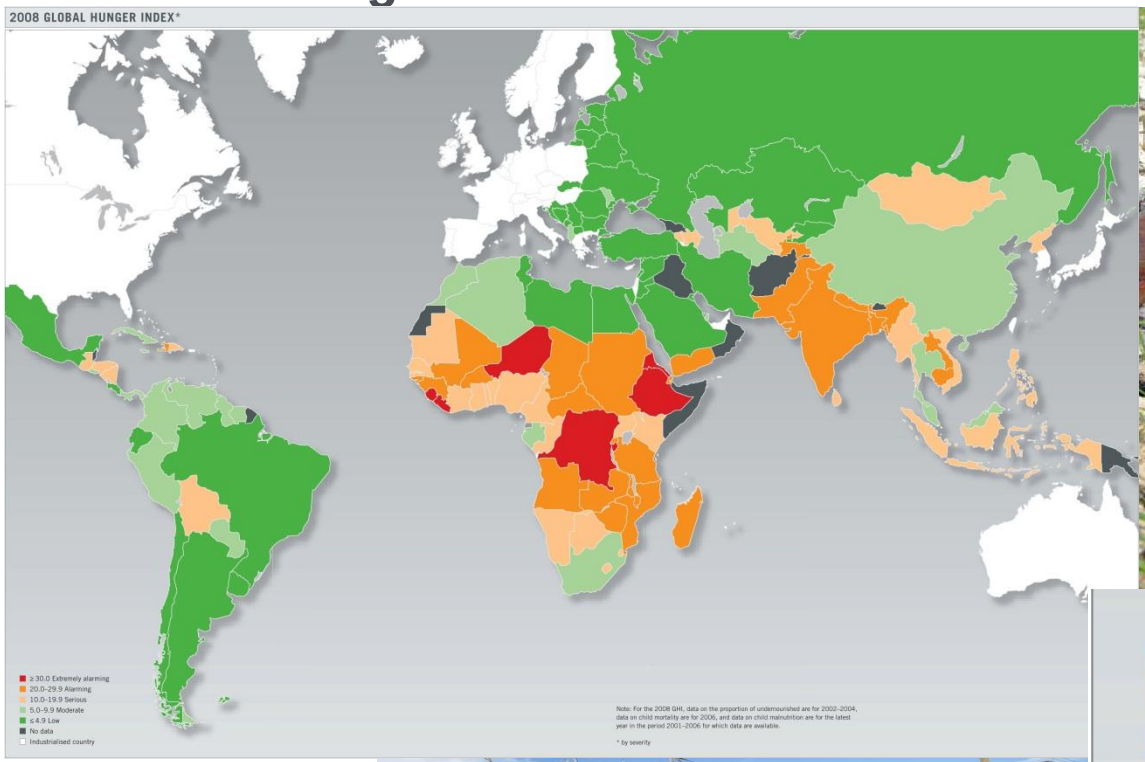
Effect of climate change on water associated disease

Effect of Droughts



Global hunger index
Welthungerhilfe 2008

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Effect of climate change on water associated disease

Effect of intense rainfall

- Similar to floods but could also:
  - Damage domestic areas
  - Damage drains, drainage systems
  - Damage to embankments
  - Damage to surges
  - Wastewater a potential source of exposure to mammary carcinogens: hypothesised to increase breast cancer risk

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Effect of climate change on water associated disease

Secondary effects: mental health

- The physical health impacts of climate change, especially infections, allergies and respiratory and cardiovascular diseases are now well recognised.
- However, the mental health impact of such change, especially in Asian countries became topical after the Asian tsunami.

- Many diverse aspects of climate and mental health:
  - seasonal climate variation and its effect on mental health
  - extreme weather conditions and their psychological impact
  - specific climatic disasters and their consequences

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Effect of climate change on water associated disease

Research to mental health linked to climate change

(source: Kumar Chand & Murthy, 2008)

- Floods:
  - A study in southern England following severe flooding in Lewes reported a four-time higher risk of psychological distress
  - Around half the children and adolescents exposed to the 'supercyclone' in Orissa (India) reported symptoms of the post-traumatic stress disorder (PTSD)
- Droughts:
  - Drought affects farmers and can contribute to severe mental agony due to financial hardship from increased debt: High rate of farmers' suicides in India is typical example
  - Drought affects family relationships. Stress, worry and the rate of suicide increase.
- Natural disaster: Following the Asian tsunami of 2005, WHO estimated:
  - 20-40% of affected people suffered from short-lasting mild psychological distress
  - 30-50% experienced moderate-to severe psychological distress
  - In Indonesia 15- 20% increase in outpatients with anxiety and depression
  - Other consequences of disasters include an increase in alcohol and drug abuse.

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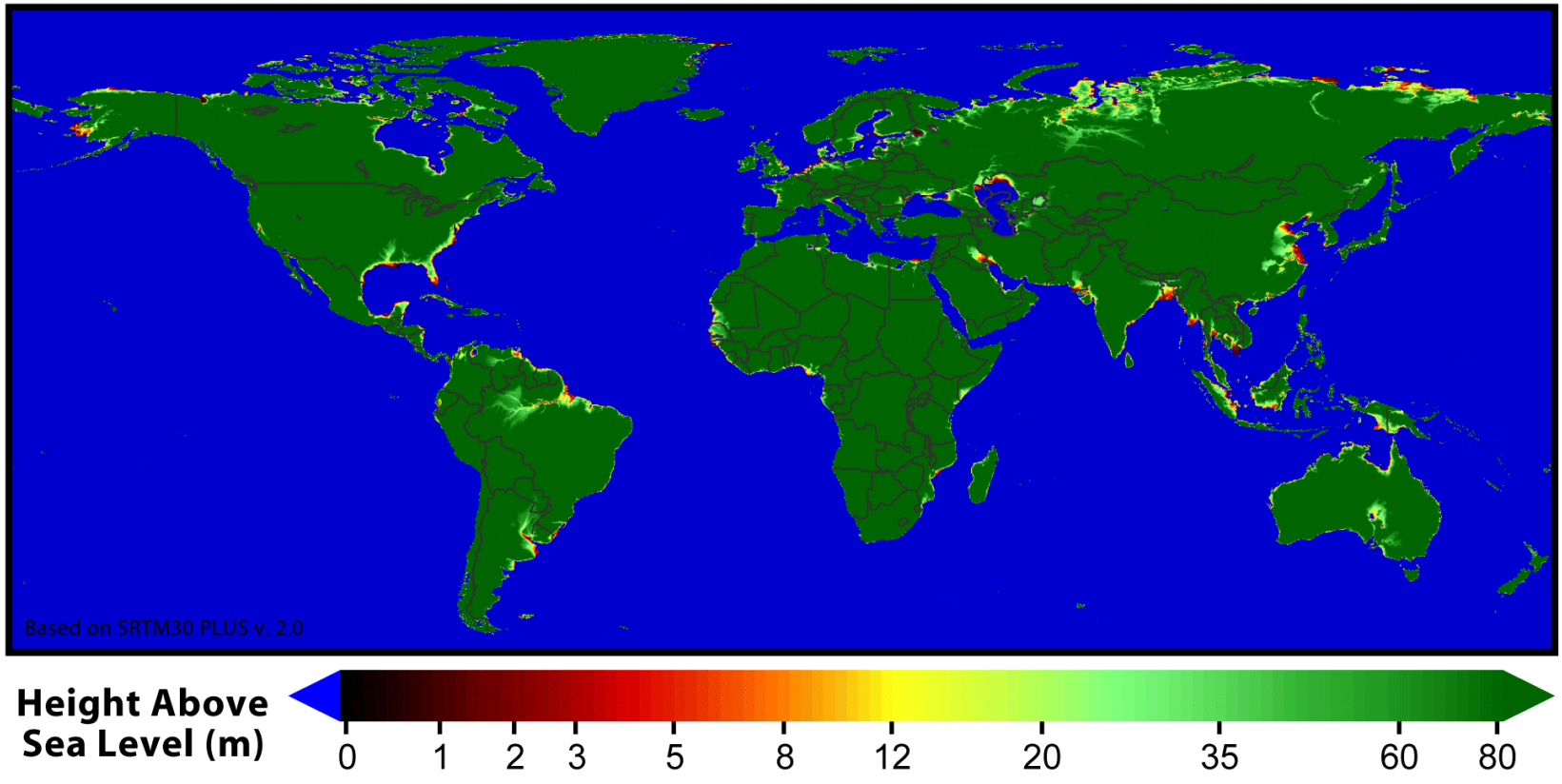
Geographical distribution of climate change effects

Which areas are effected: vulnerability to sea level rise



Global Warming Art, 2012

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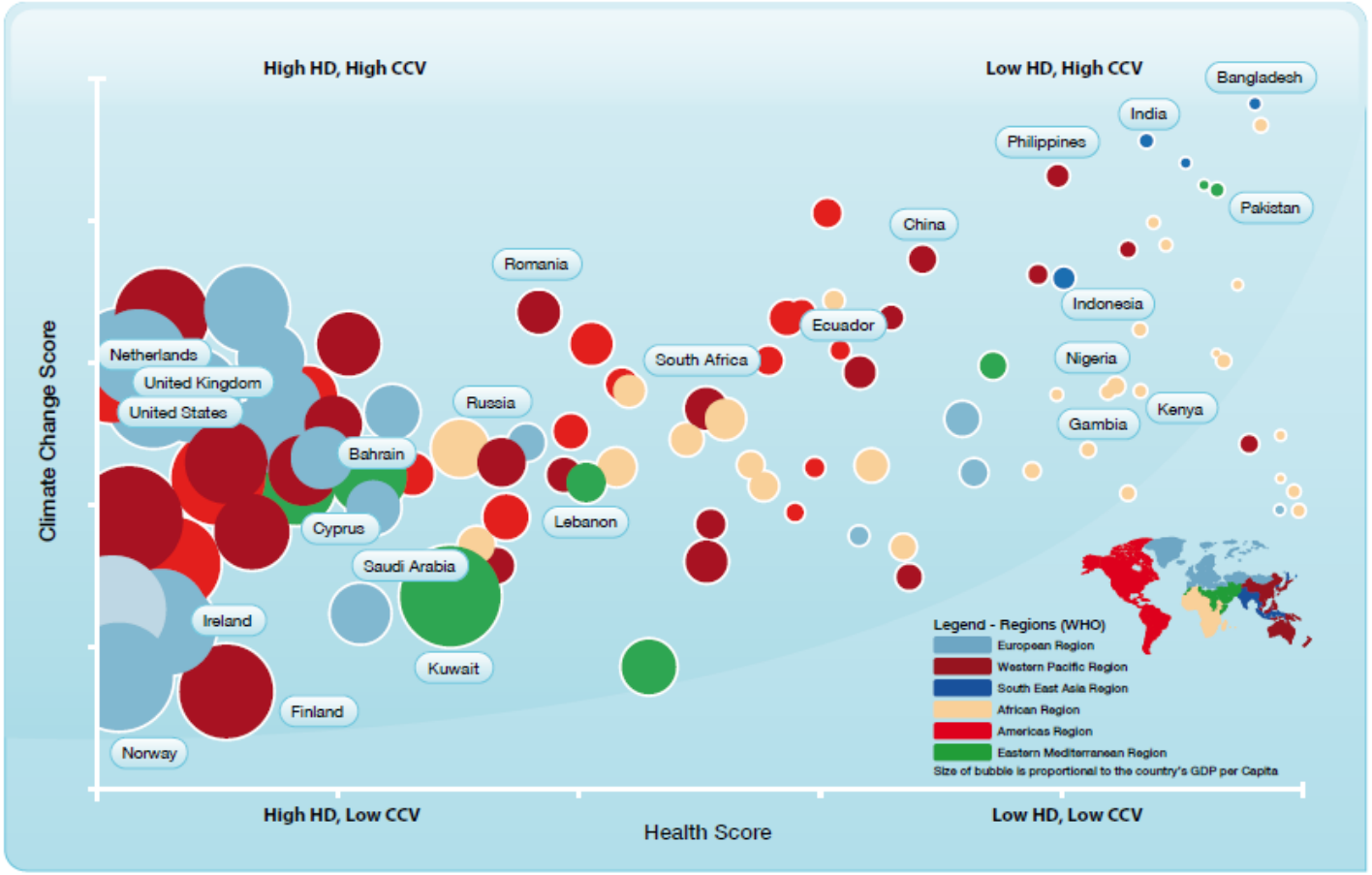
Geographical distribution of climate change effects

Which areas are effected



Climate Change and Health: Framing the Issue, GSK

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Geographical distribution of climate change effects

Which areas are effected

Diseases	Significance of climate change as a factor in determining future epidemics[1]	Existing Global Burden[2] (millions of DALYs lost)	Countries affected
 Malaria	Primary	33.98	Tropics, Sub-tropics
 Cholera	Primary	Pandemic potential	Africa, Asia, Russia South America
 Dengue	Important	0.67	Africa, Europe, South America, South East Asia
 Meningitis	Important	1.43	Worldwide
 Leishmaniasis	Important	1.97	Africa, Asia, Europe India, South America
 Influenza	Significant	Pandemic potential	Worldwide
 Diarrhoeal diseases	Significant	72.78	Worldwide
 Schistosomiasis	Significant	1.71	Africa, East Asia South America

WHO, 2005

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Predictions for the future

Predicted increase of water associated diseases under various climate change scenarios.

- No numbers given by IPCC, but main conclusions are (IPCC, 2007):
  - Climate change will affect pattern of deaths from exposure to high or low temperatures. However effect on actual disease burden cannot be quantified

  - In 2030 the estimated **risk of diarrhoea** will be 10% higher in some regions than if no climate change occurred.
  - Estimated effects on **malnutrition** vary markedly among regions.
  - The estimated proportional changes in the numbers of people **killed or injured** in coastal floods are large, although they refer to low absolute burdens.
  - Impacts of **inland floods** are predicted to increase by a similar proportion, and would generally cause a greater rise in disease burden.
  - Changes in various **vector-borne infectious diseases** are predicted: particularly for malaria in regions bordering current endemic zones. Smaller changes would occur in currently endemic areas.
  - Uncertainties **potential transmission** will become actual transmission.

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Country Profiles: India

Facts & Stats:

Climate-change vulnerability:	High
Health expenditure per capita	$29 (per year)
GDP per capita	$1,017
Main climate-related health risks:	EWEs, vector-borne diseases water scarcity and malnutrition

Current effects of climate change

- Natural disasters have caused150,000 deaths since 1980
- Heavy rainfall/floods impact health – particularly in urban areas. (July 2005 Mumbai: 944 mm /24-hour
- Flooding was exacerbated by blocked canals and drains, causing an outbreak of infectious disease, such as cholera and typhoid fever
- Prevalence of the vector-borne leptospirosis increasing eightfold.

Predicted effects in future

- Malaria zones predicted to spread to elevations above 1800m by 2080 owing to rising temperatures.
- Access to clean water and water scarcity: by 2050 there could be an estimated 38 per cent potential drop in per capita water availability.

Source: Climate Change and Health: Framing the Issue, GSK

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Country Profiles: Bangladesh

Facts & Stats:

Climate-change vulnerability:	High
Health expenditure per capita	$14 (per year)
GDP per capita	$497
Main climate-related health risks:	EWEs, TB, malnutrition, dengue diarrhoea and hepatitis A

Current effects of climate change

- Extreme risk of rising sea levels and flooding – Forced migration
- Eight major floods between 1974 – 2004 affecting up to 30 million people
- Direct costs of disasters is 1% of overall GDP

Predicted effects in future

- Increase in food and waterborne diseases – Hepatitis A&E, protozoal diarrhoea and typhoid fever
- Vector-borne diseases – especially dengue fever and malaria – are expected to show higher incidences.
- A total of 14.7 million people in Bangladesh are classified as high-risk in terms of catching malaria.

Source: Climate Change and Health: Framing the Issue, GSK

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Country Profiles: Kenya

Facts & Stats:

Climate-change vulnerability:	High
Health expenditure per capita	$30 (per year)
GDP per capita	$783
Main climate-related health risks:	Malaria, NTDs and water scarcity

Current effects of climate change

- Susceptible to floods, droughts, landslides and fires
- Drought is most common: 70% of land is affected by drought
- Mainly children affected in arid north: 30% malnourished
- Floods occur seasonally

Predicted effects in future

- Increase in risk of food and waterborne diseases: diarrhoea, Hepatitis A, typhoid fever
- Also increase in risk of malaria, dengue, Rift Valley Fever
- Rainfall is expected to be more intense; higher temperatures add to risk of malaria and RVF epidemic

Source: Climate Change and Health: Framing the Issue, GSK

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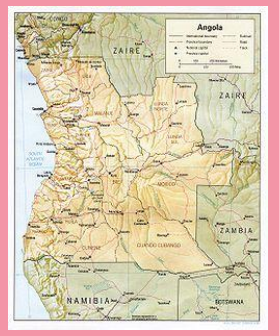
Country Profiles: Angola

Facts & Stats:

Climate-change vulnerability:	High
Health expenditure per capita	$105 (per year)
GDP per capita	$4714
Main climate-related health risks:	EWEs, diarrhoea, Hepatitis A malaria, schistosomiasis



Current effects of climate change

- Increased number of warm spells.
- Significant increase in heavy rainfall
- Periodic floods; in 2009, 80000 people were displaced, 220000 people affected

Predicted effects in future

- Increase in risk of food and waterborne diseases such as protozoal diarrhoea, hepatitis A, typhoid fever
- Increase in risk of vectorborne diseases such as HAT (sleeping sickness) & malaria, as well as water related diseases such as schistosomiasis
- Cholera and respiratory infections will increase significantly

Source: Climate Change and Health: Framing the Issue, GSK

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Coping Strategies

National strategies for climate change preparedness

Some examples (will come back in seminar)

- Adaptation strategies for extreme weather events
  - early warning systems
  - zoning and planning to avoid building in at-risk areas
  - reinforcing the built environment against hazardous weather events
  - evacuation planning.

- Measures to protect natural barriers to flooding and erosion and to buffer storm surge, will:
  - decrease magnitude of adverse exposures
  - maintain associated ecosystem services such as food production and waste assimilation
  - potential co-benefits of climate change adaptation

- High population growth, in areas vulnerable to storm surges and sea-level rise will make adaptation difficult.

Questions