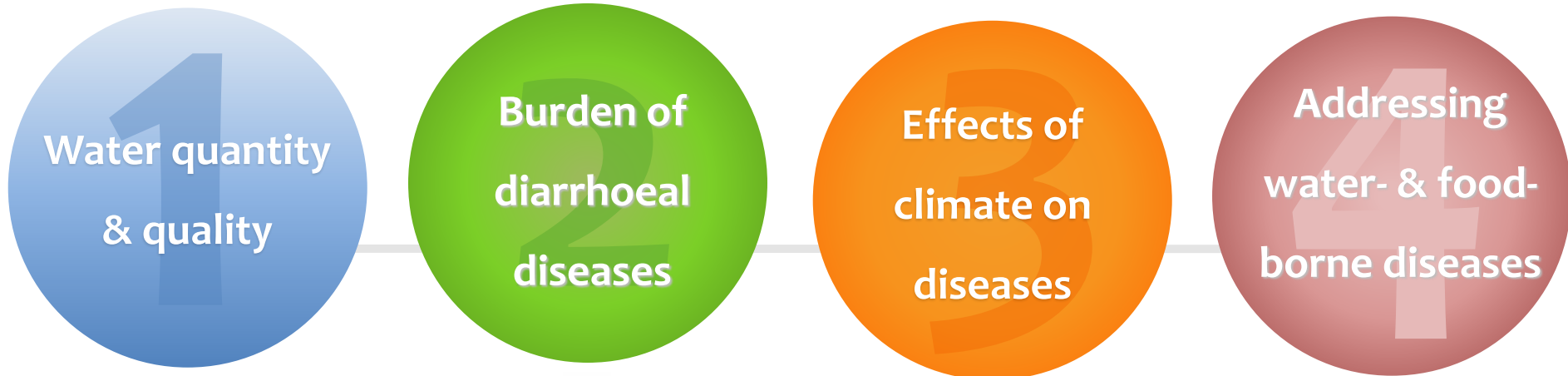# Module 8: Water-borne diseases

Key messages in Module 8

- Water-borne diseases are mostly faecal-orally transmitted diseases

- Climate can influence waterborne diseases in different ways depending on the local environment & population

- Mitigation & adaptation will be enhanced by understanding the ecology of pathogens
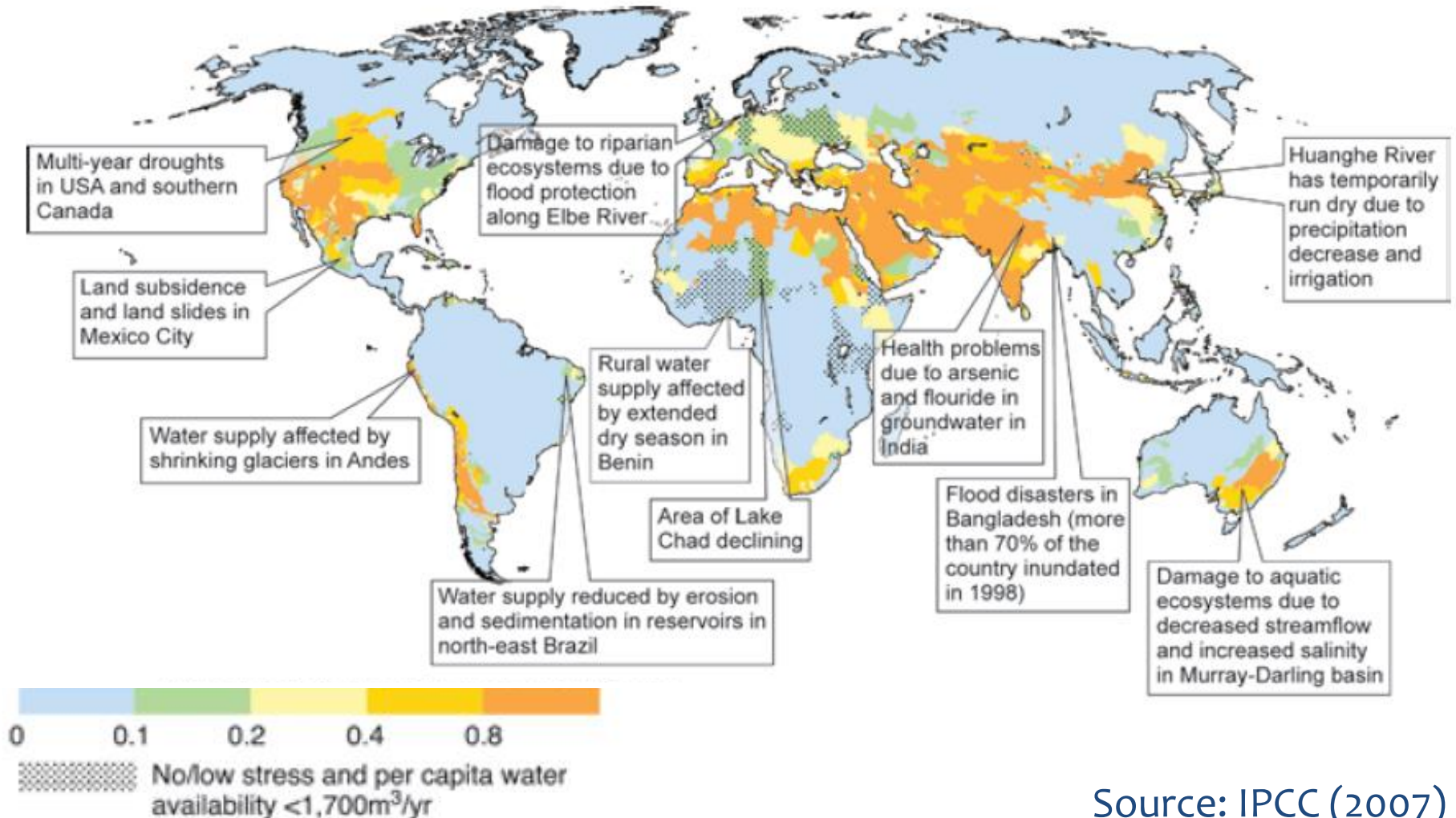
Module 8 outline

1 Water quantity & quality

2 Burden of diarrhoeal diseases

3 Effects of climate on diseases

4 Addressing water- & food-borne diseases

3

1

Water quantity & quality

Water quantity & quality issues

Examples of current vulnerabilities of freshwater resources

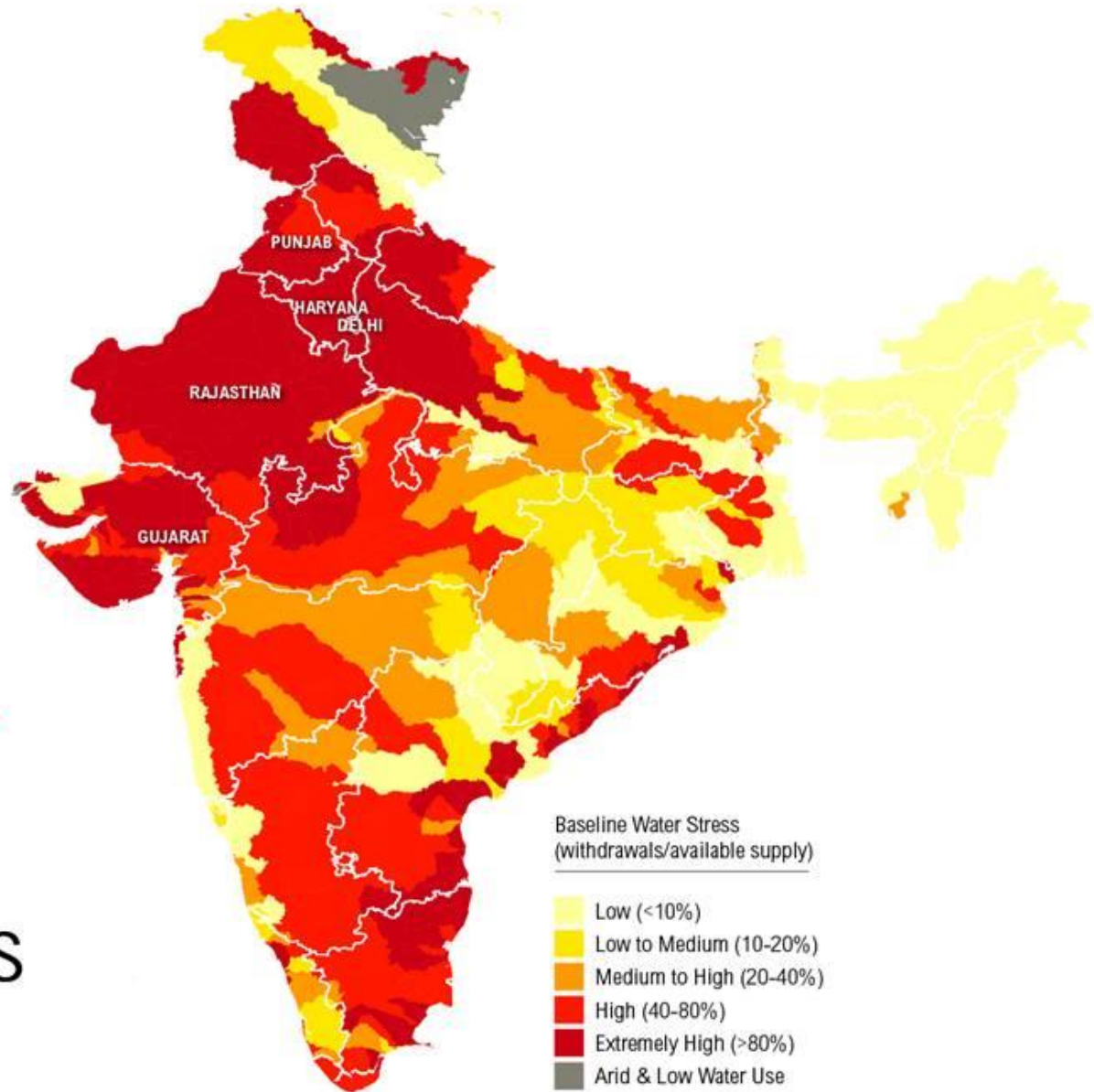Multi-year droughts in USA and southern Canada

Damage to riparian ecosystems due to flood protection along Elbe River

Huanghe River has temporarily run dry due to precipitation decrease and irrigation

Land subsidence and land slides in Mexico City

Water supply affected by shrinking glaciers in Andes

Rural water supply affected by extended dry season in Benin

Health problems due to arsenic and flouride in groundwater in India

Area of Lake Chad declining

Flood disasters in Bangladesh (more than 70% of the country inundated in 1998)

Damage to aquatic ecosystems due to decreased streamflow and increased salinity in Murray-Darling basin

Water supply reduced by erosion and sedimentation in reservoirs in north-east Brazil

0   0.1   0.2   0.4   0.8

No/low stress and per capita water availability <1,700m^3/yr

54%

of India Faces **High** to **Extremely High** Water Stress

Baseline Water Stress
(withdrawals/available supply)

- Low (<10%)
- Low to Medium (10-20%)
- Medium to High (20-40%)
- High (40-80%)
- Extremely High (>80%)
- Arid & Low Water Use

PUNJAB

HARYANA
DELHI

RAJASTHAN

GUJARAT

Water-related diseases

Category	Transmission	Disease examples
Water-borne	Ingestion of water contaminated by human or animal faeces or urine containing pathogenic bacteria, viruses or parasites	Gastroenteritis, enteric hepatitis, amoebic & bacillary dysentery, cholera, leptospirosis, poliomyelitis, typhoid/paratyphoid fever
Water-washed	Skin, ear or eye contact with contaminated water & poor personal hygiene	Conjunctivitis, trachoma, intestinal helminth infections, leprosy, scabies
Water-aerosol disease	Inhalation of water aerosol containing pathogen	Legionellosis, phiesteria
Water-based	Parasitical worm infections (parasites found in intermediate organisms living in water)	Dracunculiasis, schistosomiasis, (tricho)bilharziasis
Water-related arthropod vector	Insect vectors breeding in water or biting near water	Dengue, lymphatic filariasis, malaria, onchocerciacis, trypanosomiasis, yellow fever

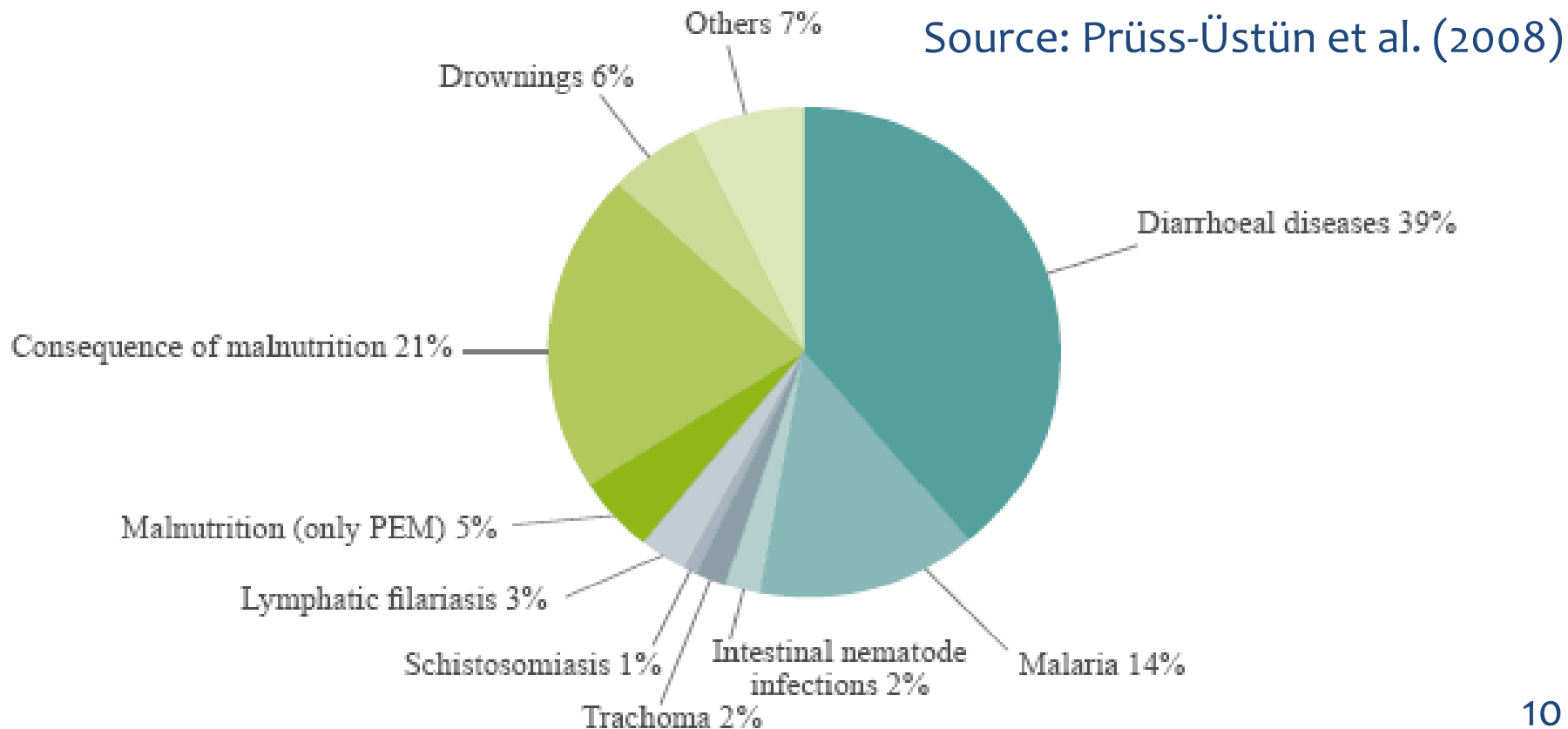# Diarrhoeal disease pathways: Fecal-oral transmission

2

Burden of diarrhoeal diseases

WHO/UNICEF JOINT STATEMENT

CLINICAL MANAGEMENT OF ACUTE DIARRHOEA

unicef
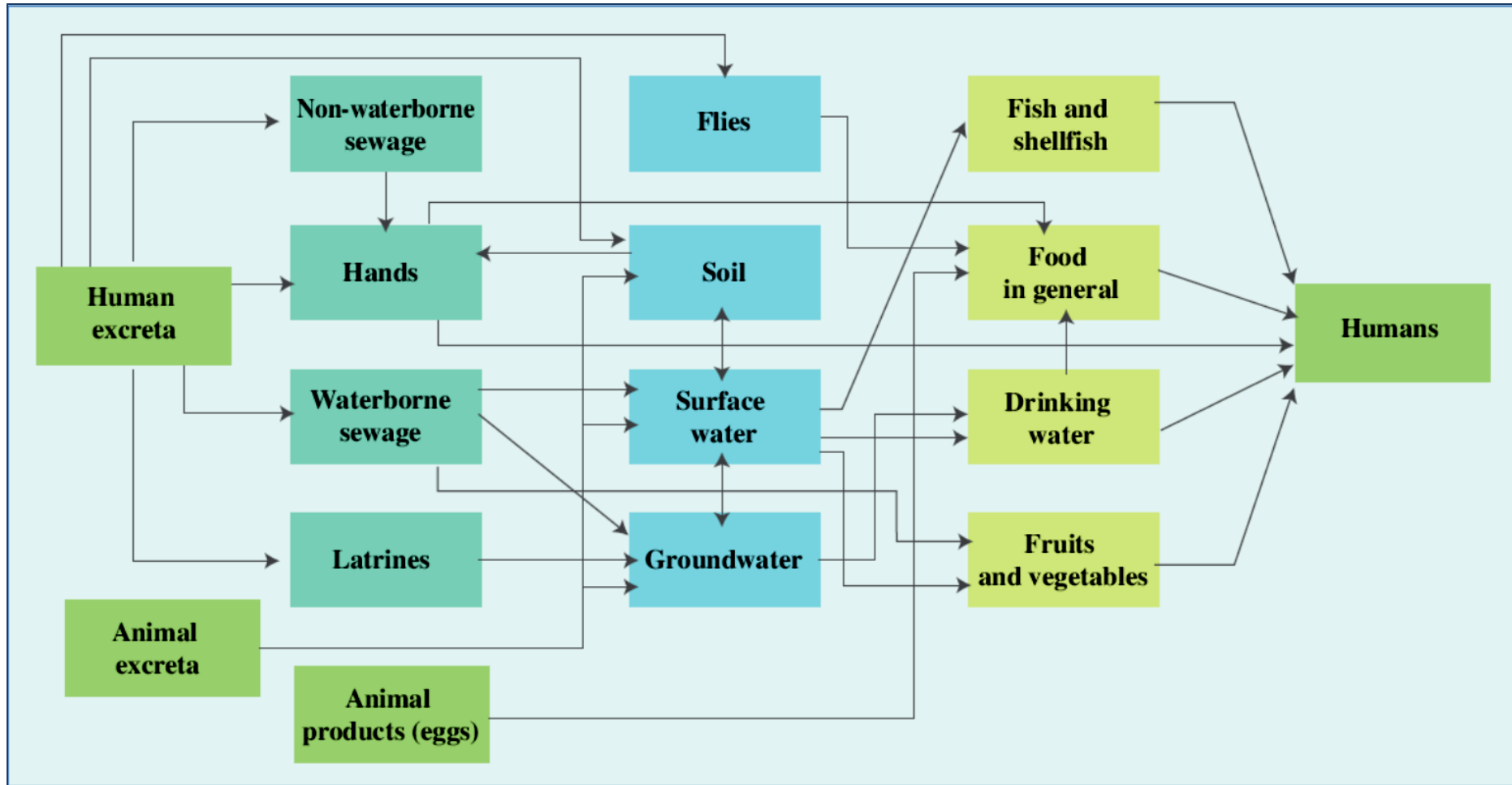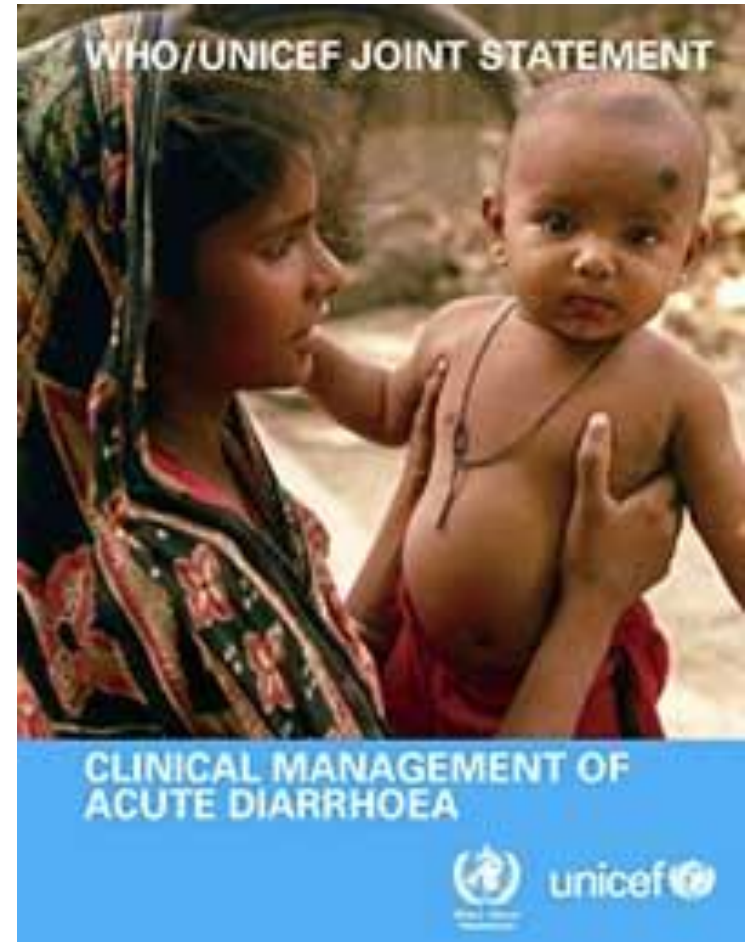
Burden of water-borne disease

- 1.8 million deaths - 4 million cases- in 2004 due to gastroenteritis (WHO)
- 88% due to unsafe water & poor sanitation

Source: Prüss-Üstün et al. (2008)

Others 7%

Drownings 6%

Diarrhoeal diseases 39%

Consequence of malnutrition 21%

Malnutrition (only PEM) 5%

Lymphatic filariasis 3%

Schistosomiasis 1%

Intestinal nematode infections 2%

Malaria 14%

Trachoma 2%

Burden of diarrhoeal diseases related to WSH

In 2016, water, sanitation and hygiene was responsible for 829 000 annual deaths from diarrhoea and 1.9% of the global burden of disease (DALYs)

Improvements related to drinking-water, sanitation, hygiene and water resource management could result in the reduction of almost 10% of total burden of disease worldwide

DALYs due to Diarrhoeal Diseases, India
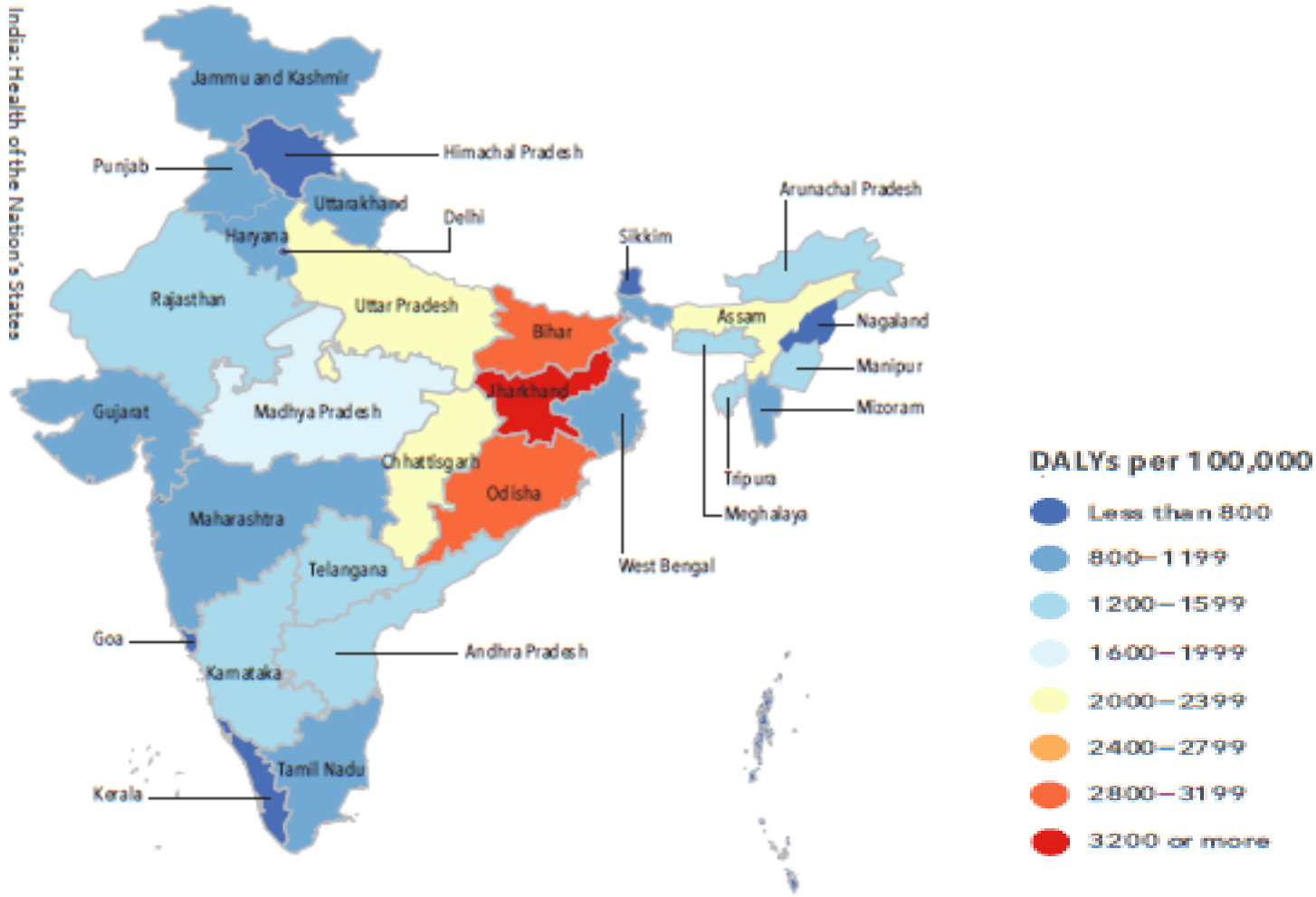
In addition to diarrhoea, an important share of the following diseases could be prevented if adequate water quality and quantity, sanitation facilities, hygiene behaviour, as well as water resource management interventions were implemented:

- Malnutrition
- Intestinal nematode infections
- Lymphatic filariasis
- Trachoma
- Schistosomiasis
- Malaria
- Other infectious diseases

Diseases with largest water, sanitation & hygiene contribution (% global disease burden) (2002)
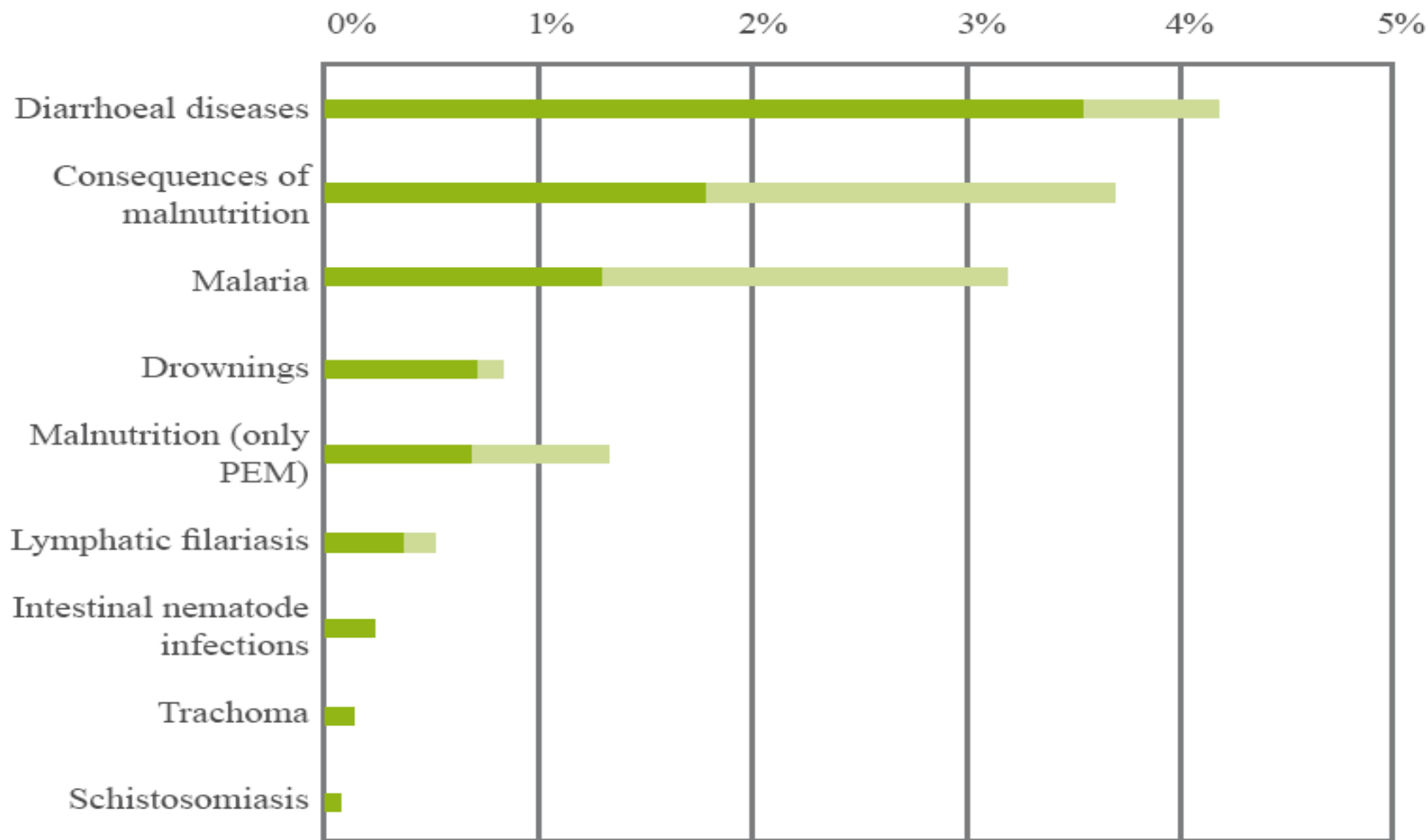
Source: Prüss-Üstün et al. (2008)14

No. of additional deaths from diarrhoea in 0-15 years of age, worldwide
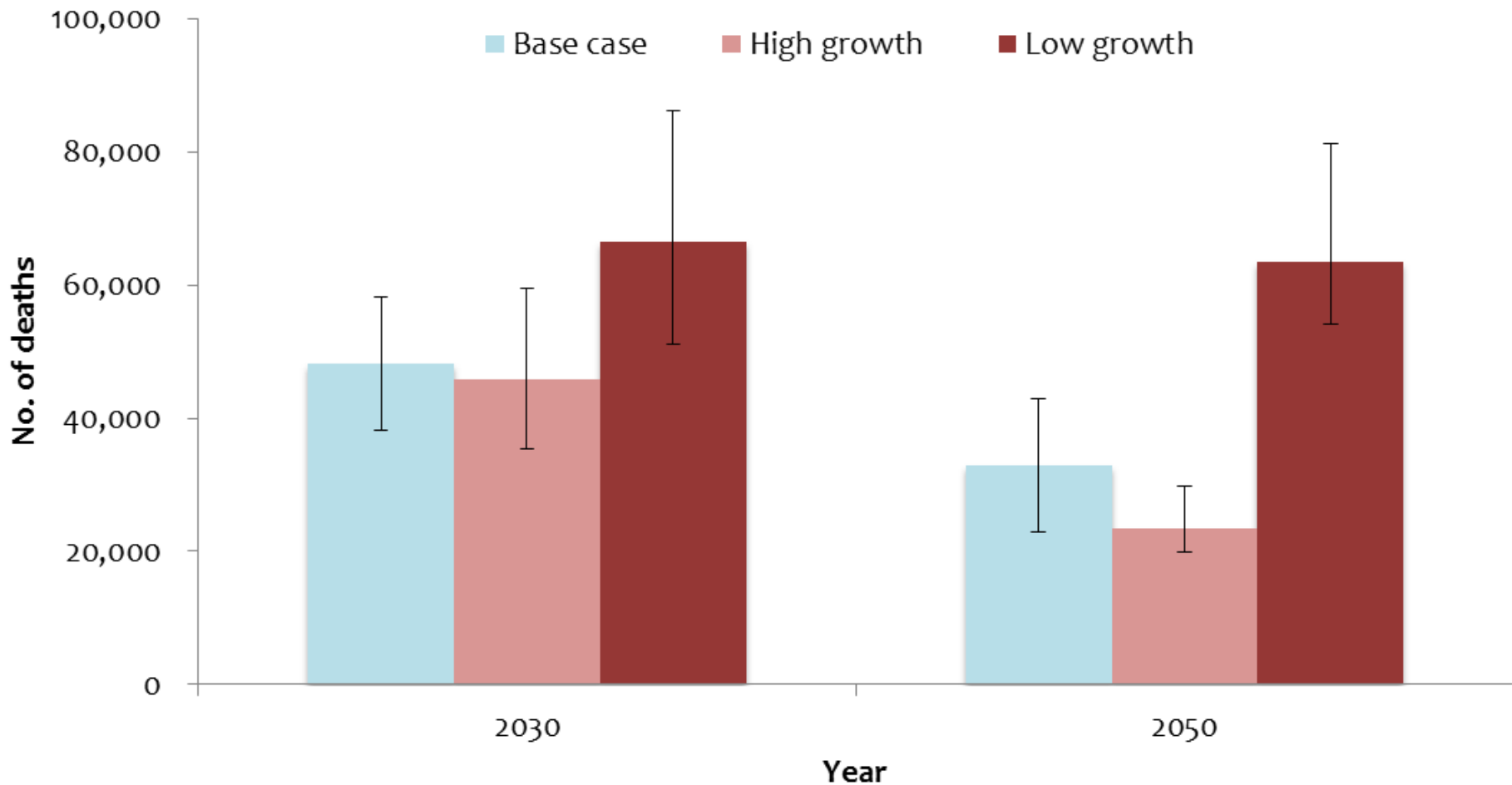
How climate & weather affects water-borne disease

How climate influences waterborne disease trends

Local temperature	• Replication in the environment or associated with food products • Persistence
Local rainfall	• Loading into the environment (contamination) • Increased concentration of contaminants (drought)
Changes in hydrologic cycle	• Increased drought • Increased storm intensity
Change in frequency of 'extreme events'	• Hurricanes • Ocean-atmosphere oscillations: ENSO, IOD, others
Sea level rise	• Influx of marine pathogens • Flooding (storm surge), contamination, loss of infrastructure

3

How climate & weather affects food- & water-borne disease: Seasons

Seasonal trends in Rotavirus infections
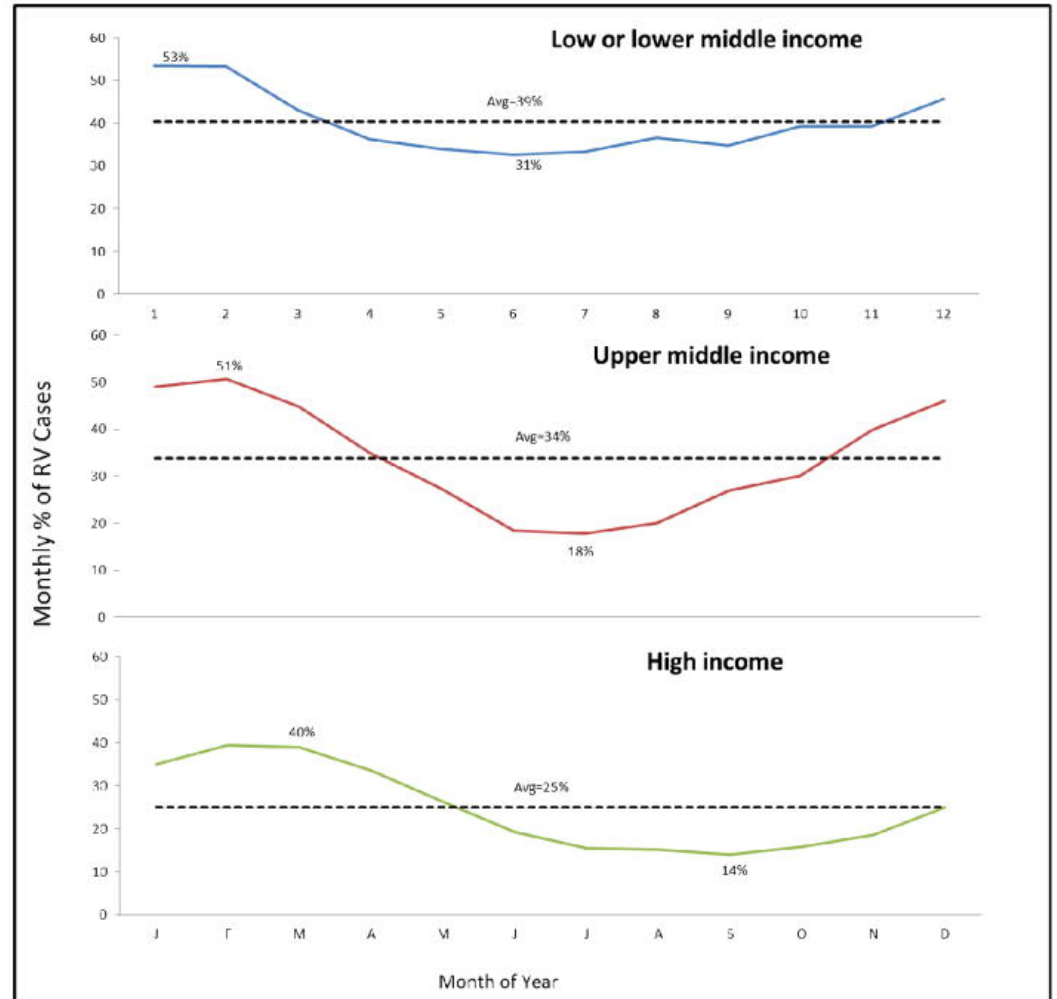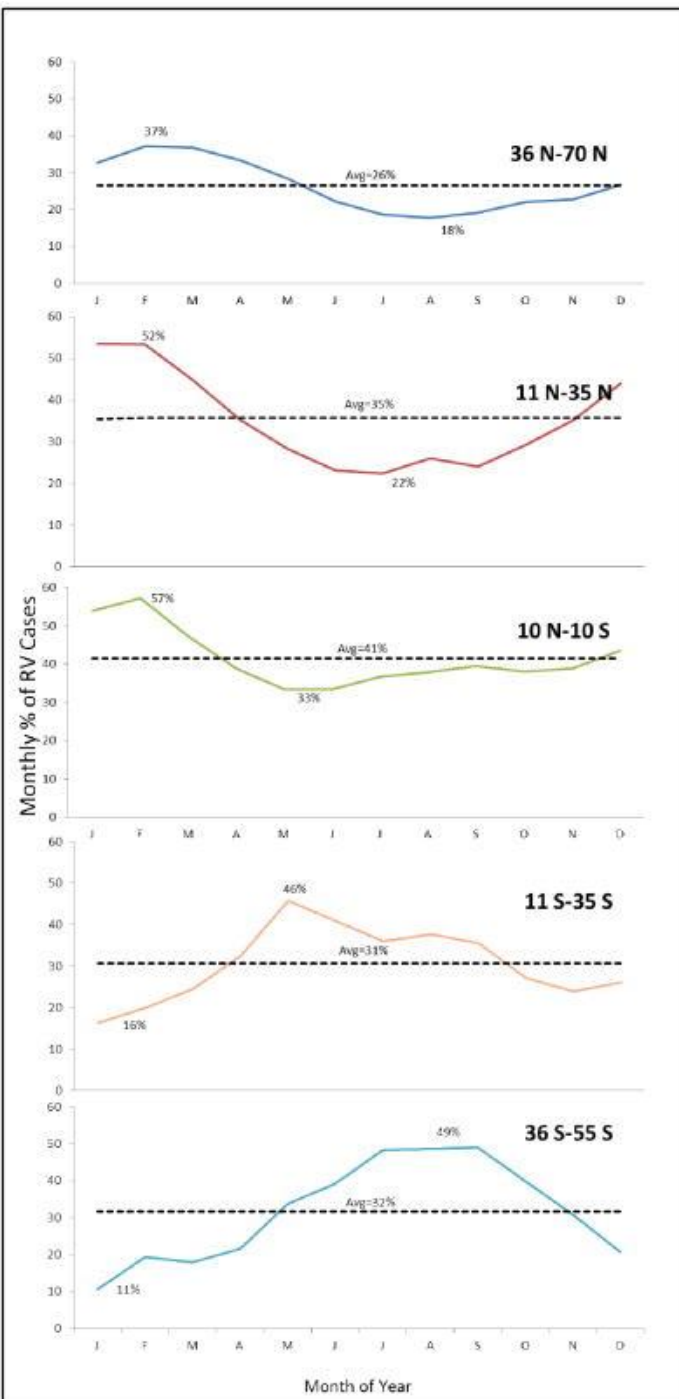
Seasonal patterns of Salmonellosis

3
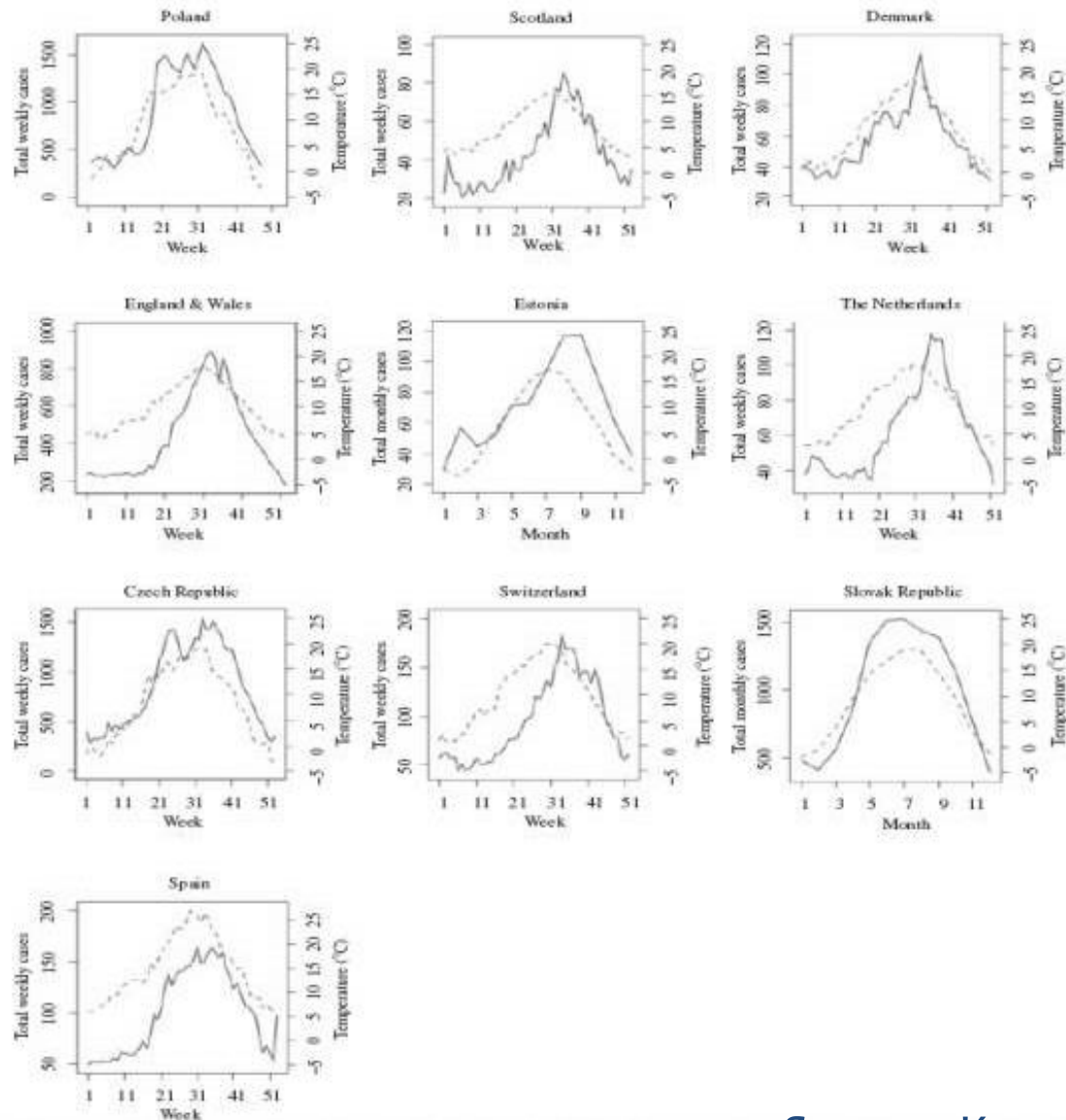
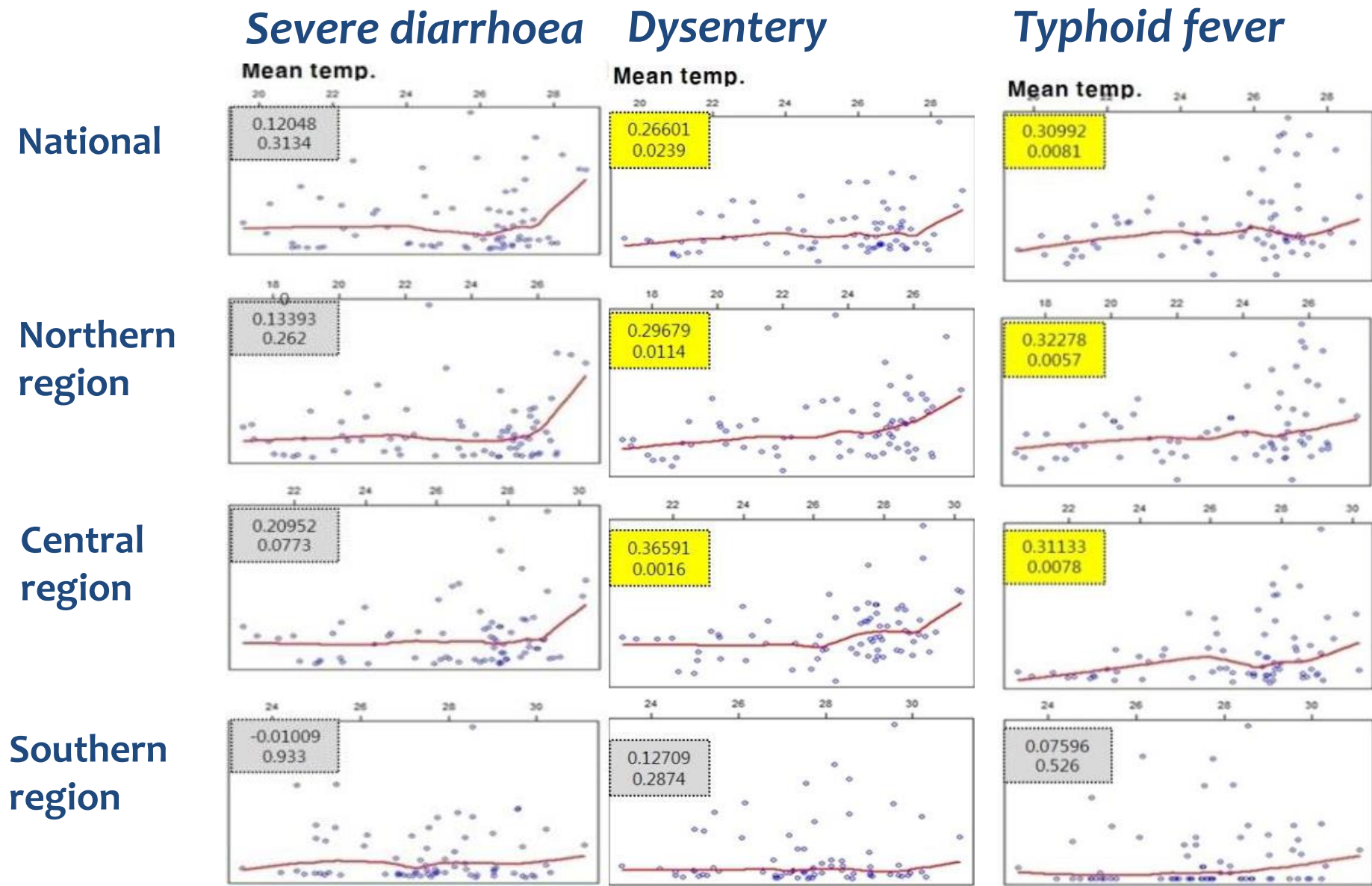# How climate & weather affects food- & water-borne disease: Temperature

Annual temperature & reported diarrhoeal disease, Pacific Islands (1986 – 1994)
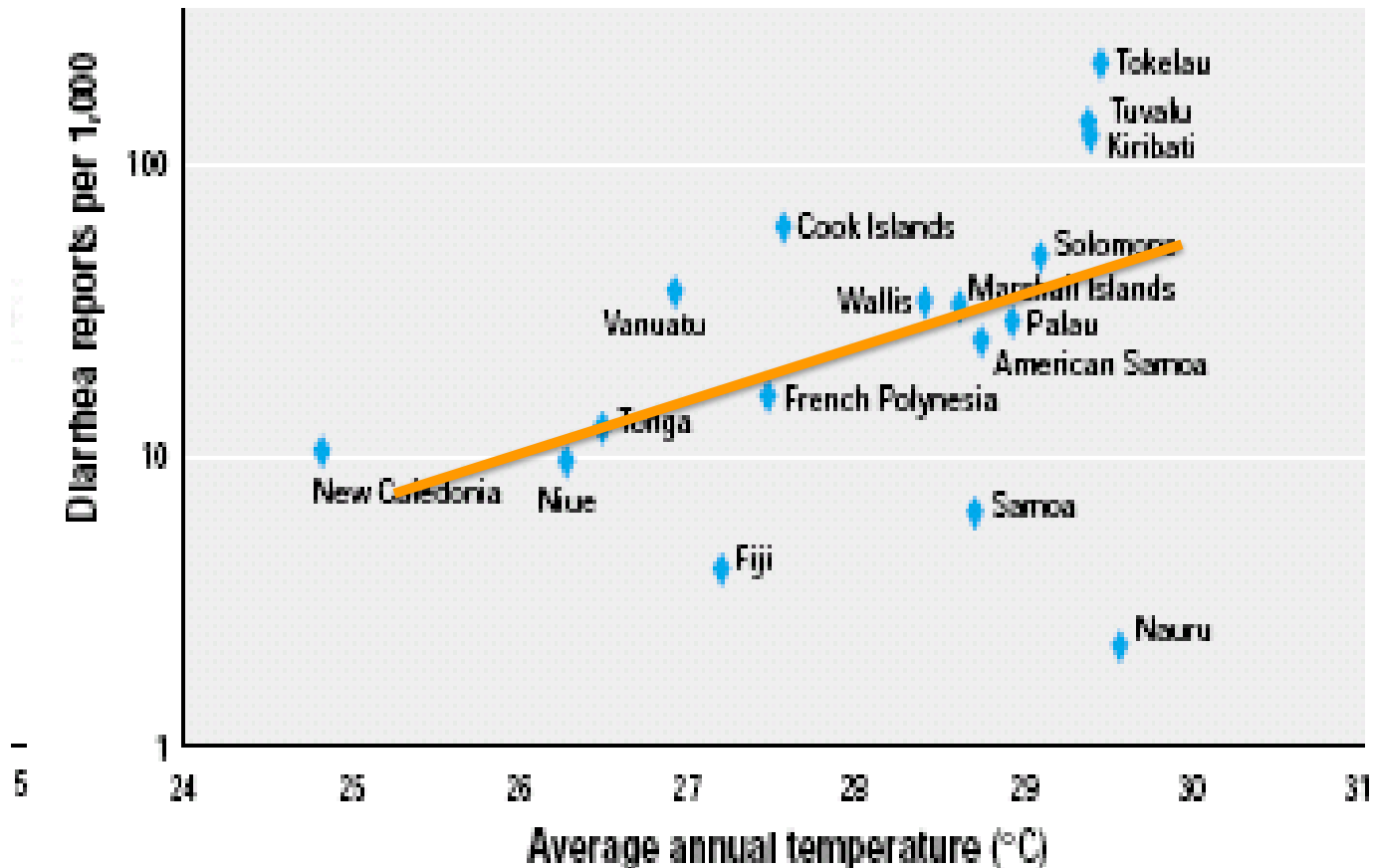
3% increase of diarrhoea for each 1°C increase in the previous month

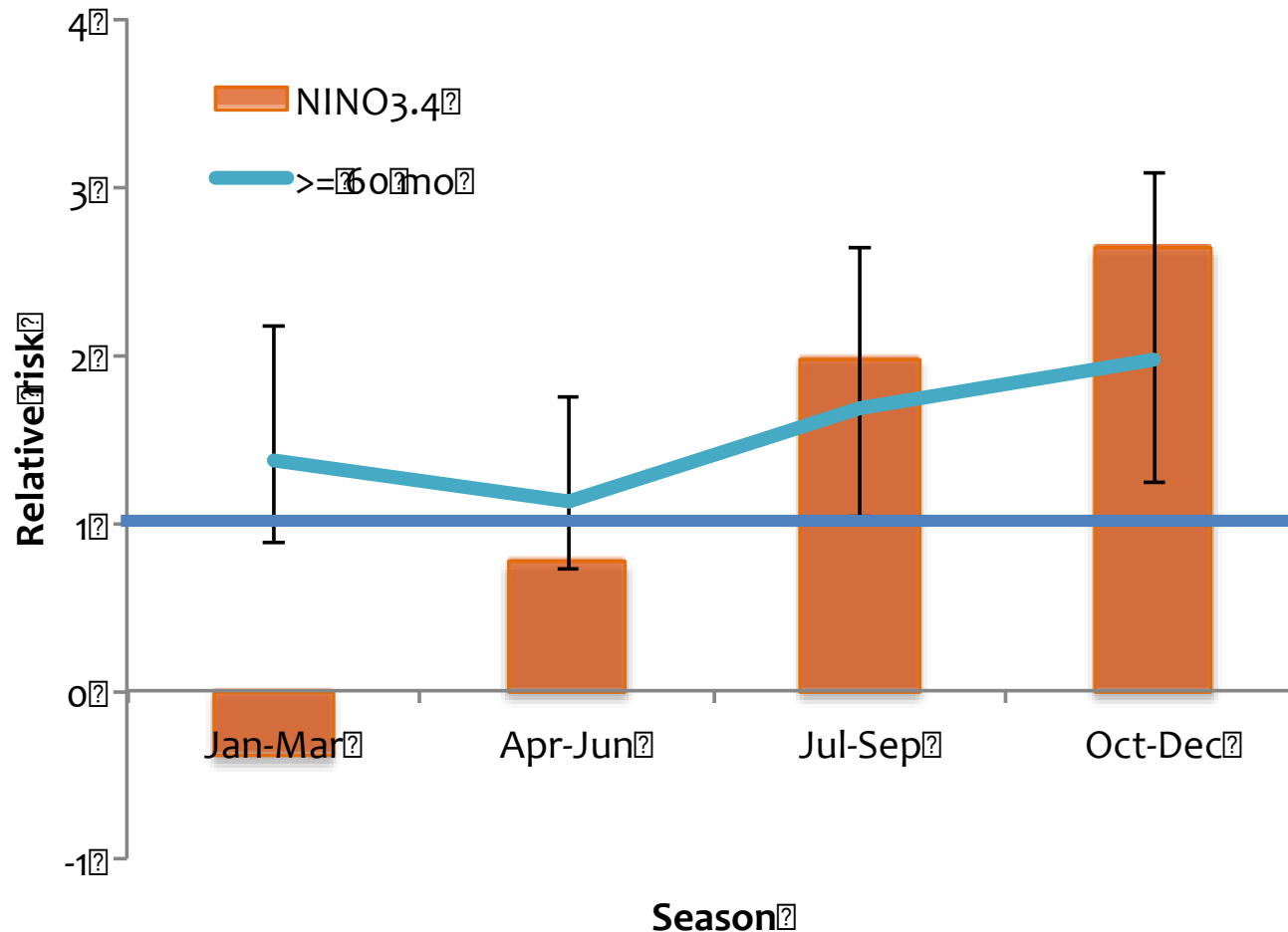# Correlation of temperature & water-borne diseases in Lao PDR

Source: Fengthong et al. (2005)

3

How climate & weather affects food- & water-borne disease: **Precipitation**

Severe 1997-1998 El Niño episode & diarrhoeal disease incidence in children ≥60 months of age in Lima Peru, 1995-1998

Local rainfall influences levels of pathogens in water & exposure risk to humans

- Run-off
- Flooding
- Drought

Flooding: Risk factors

- Direct contact with contaminated water
  - Skin
  - Respiratory
  - Ear & eye infections

- Ingestion of contaminated water (wells etc.)
  - Gastroenteritis

- Insufficient water treatment (i.e. problem at the tap)

- Additional secondary spread
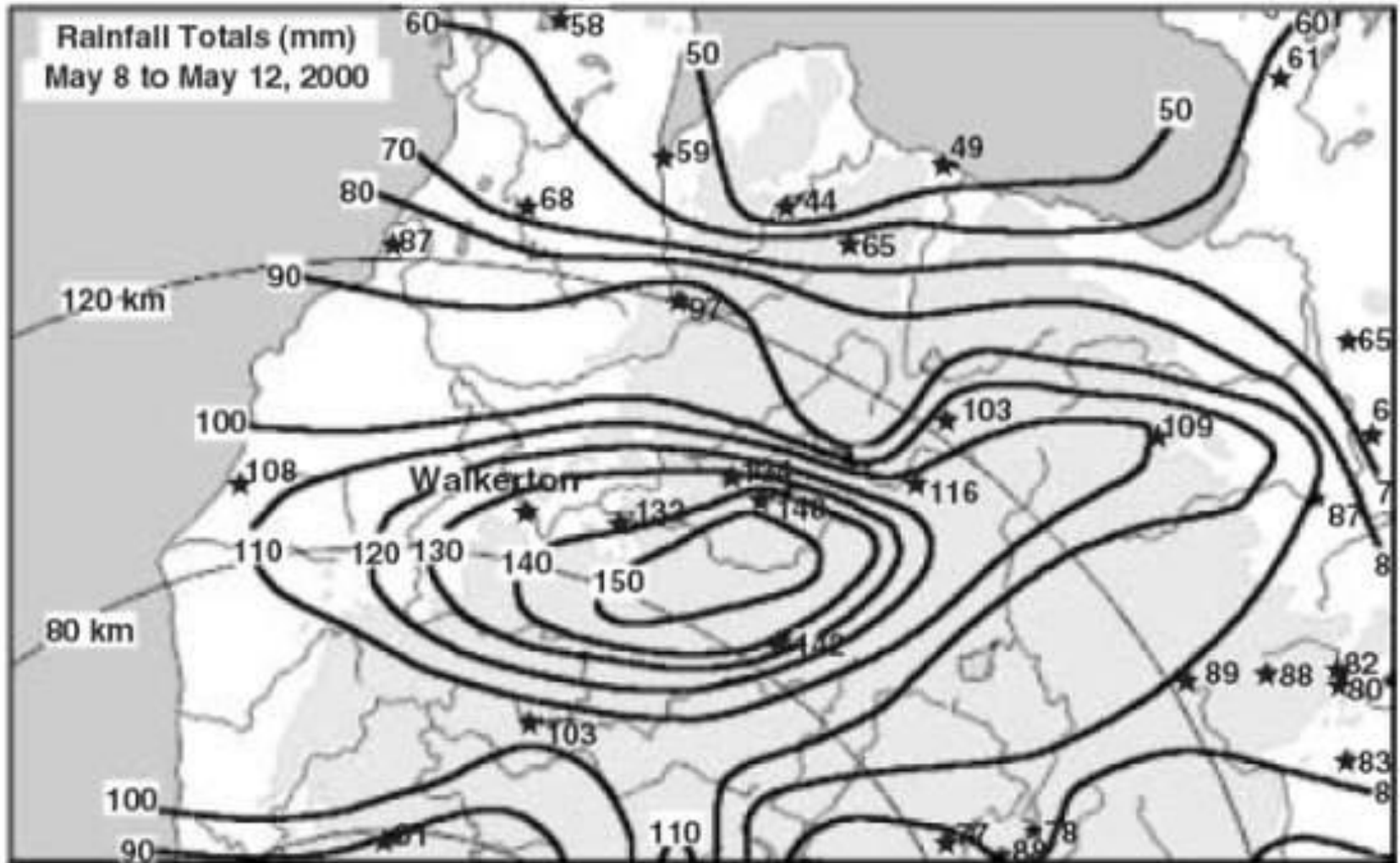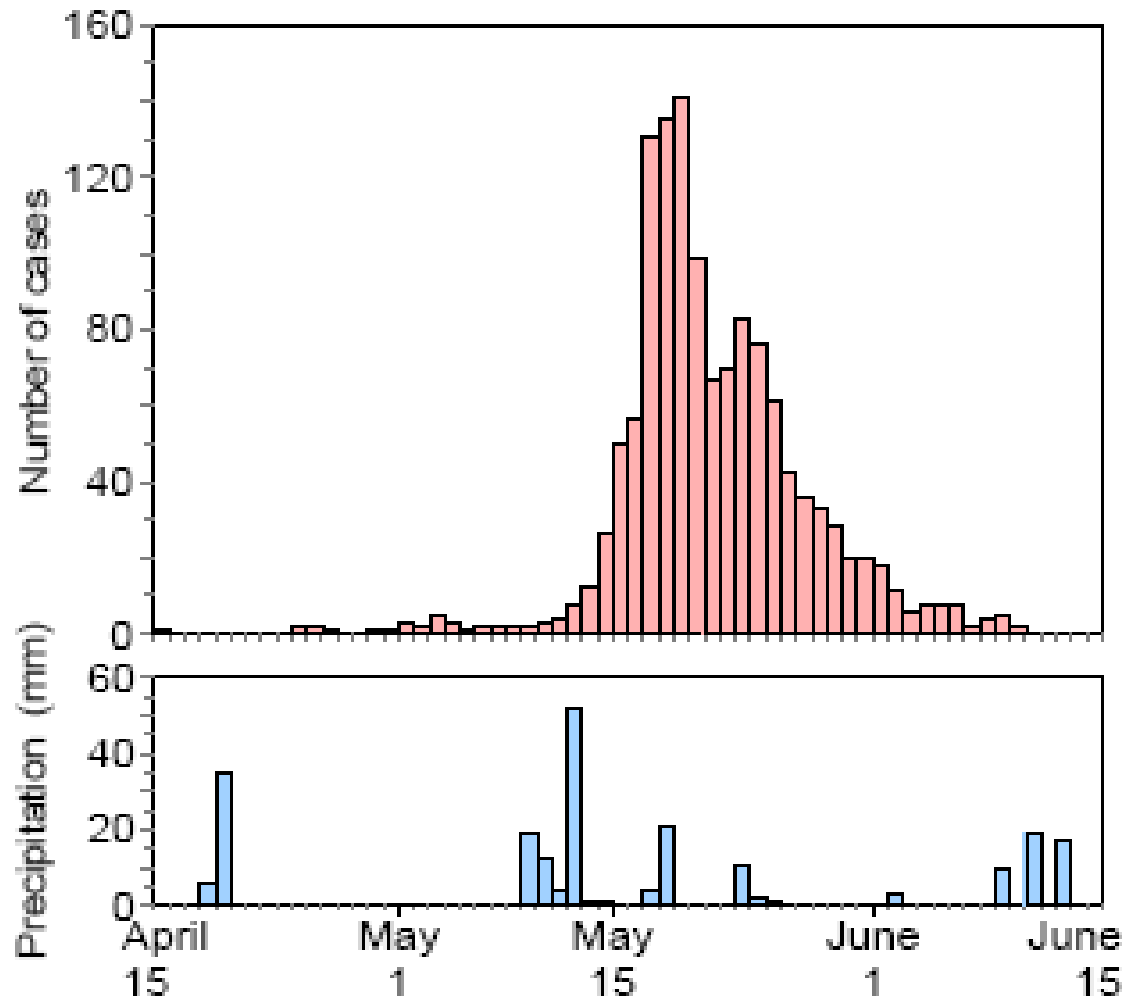
Climate change & flooding

(A)
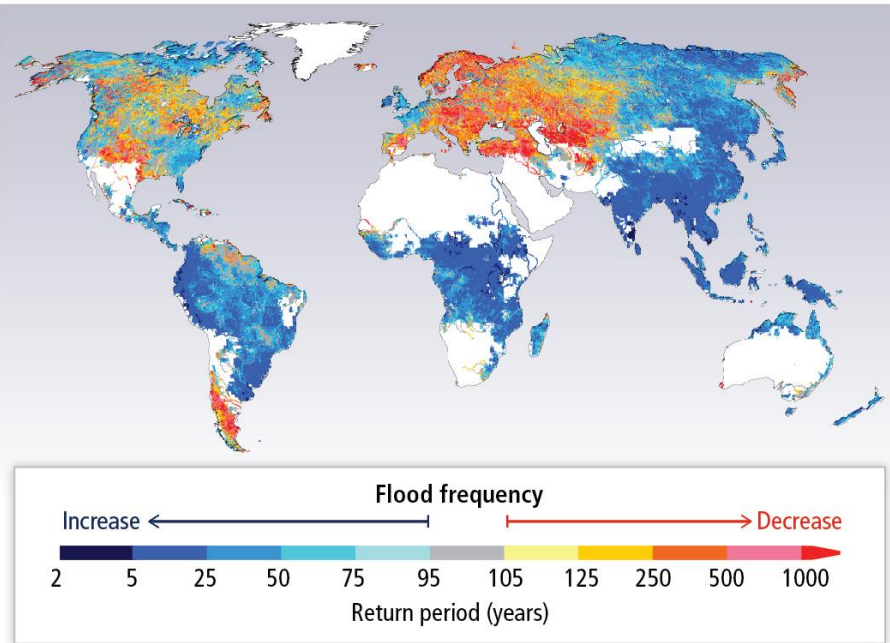
(B)
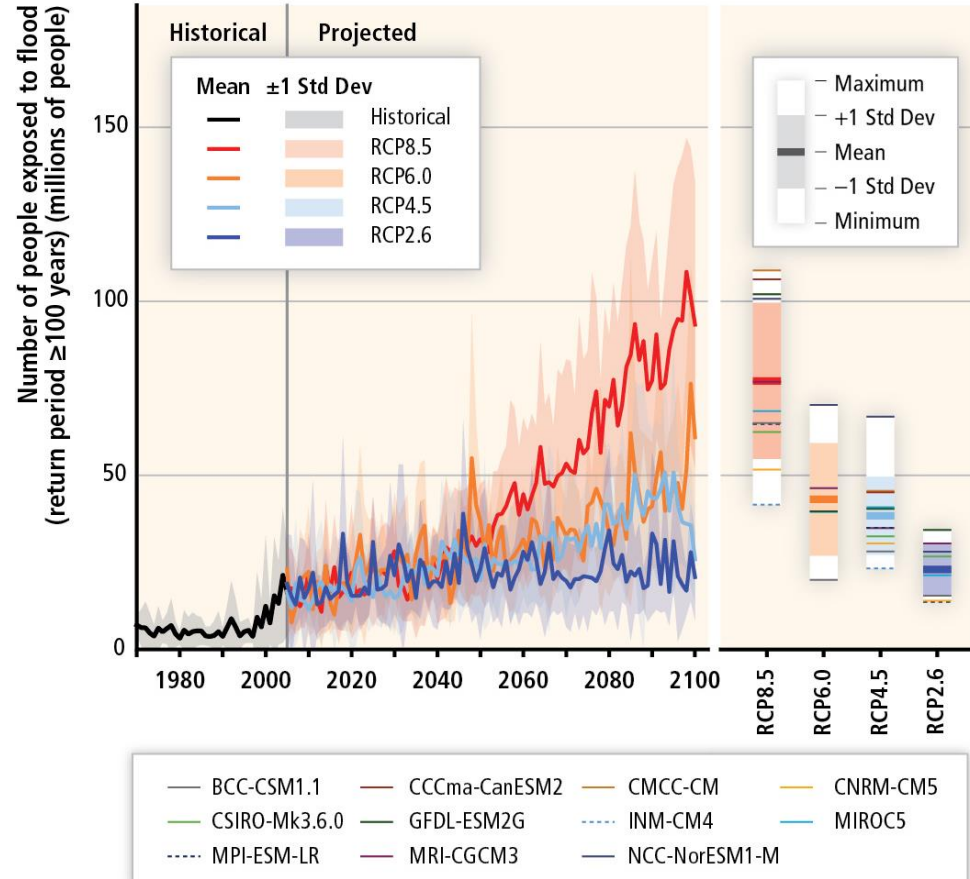
Extreme precipitation & water-borne disease outbreaks

Watershed outbreak location
Extreme precipitation
Hydrologic region boundary
State boundary

Source: Curriero et al. (2001)
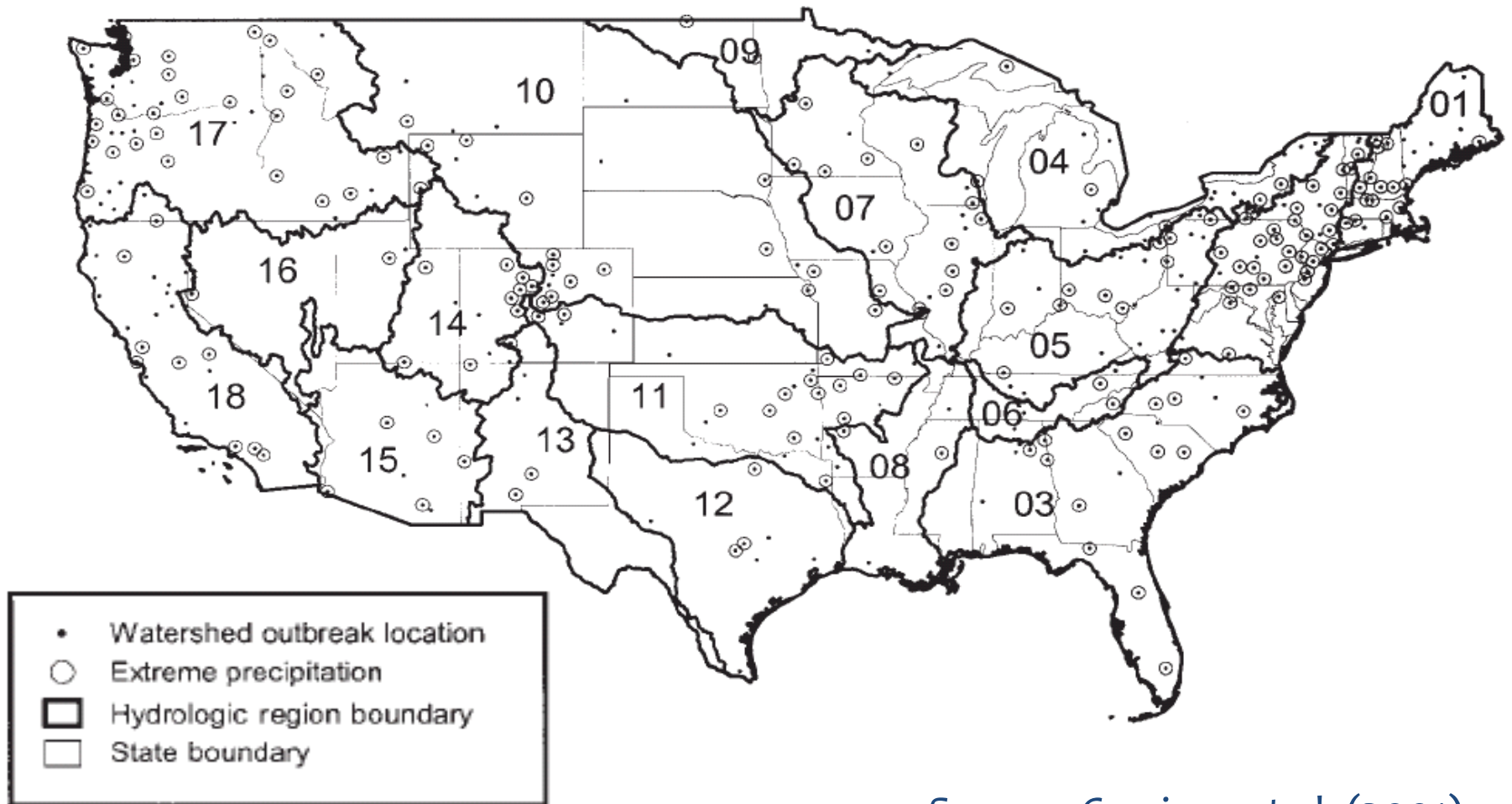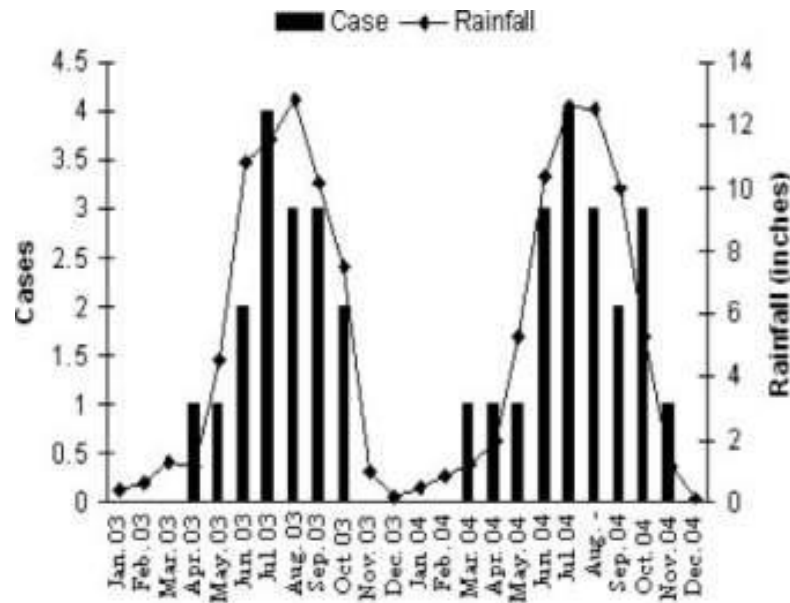
E.g. Walkerton (Canada) rainfall, 2000

E.g. Walkerton (Canada) outbreak
Illness onset dates & precipitation

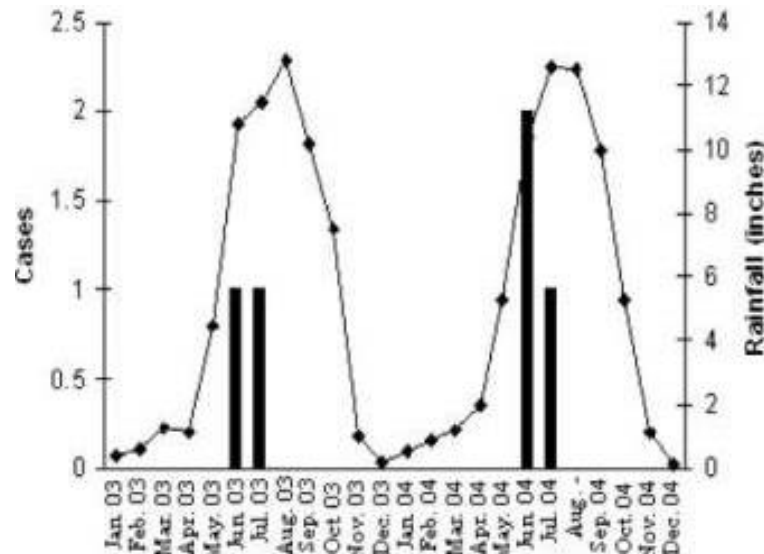# Cryptosporidiosis & precipitation

C. hominis → Months A

Other *Cryptosporidium* spp. → Months B

Source: Das et al. (2006)

Rainfall, run-off & pathogen contamination

- Building evidence for the association between diarrheal disease & increased precipitation, especially with heavy rainfall events

- In addition, several studies note increased pathogen loads related to floods, run-off, & heavy precipitation including:
  - Enteric viruses (e.g. enteroviruses, noroviruses, adenoviruses)
  - Protozoan parasites (e.g. *Cryptosporidium*, *Giardia*, others)
  - Enteric bacteria (e.g. *Salmonella*, *Campylobacter*, *E. coli*, fecal indicator bacteria)

Drought effects on water quality
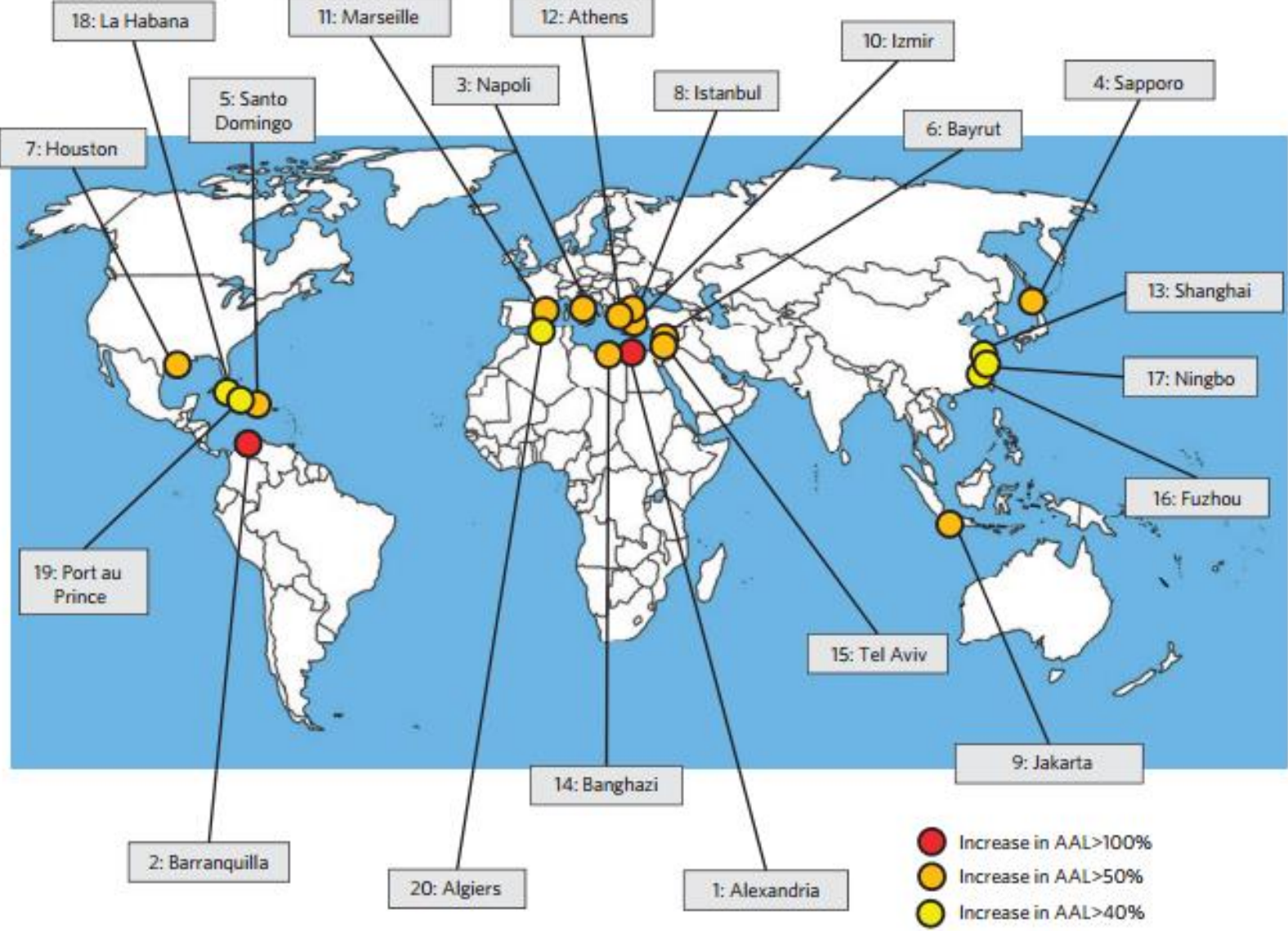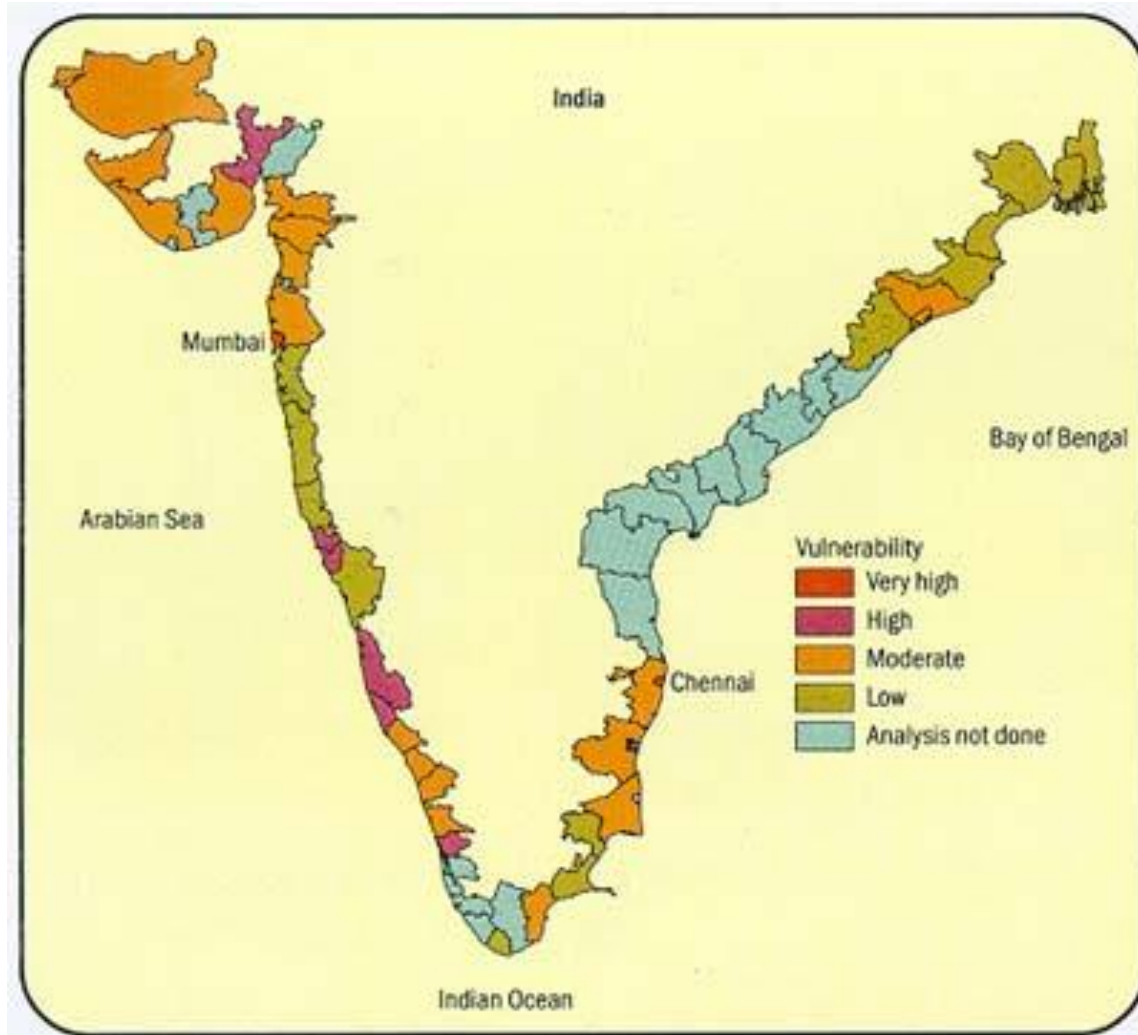## Correlation between storage level & supplies with water quality issues

Source: CRCWQT (2005) 34
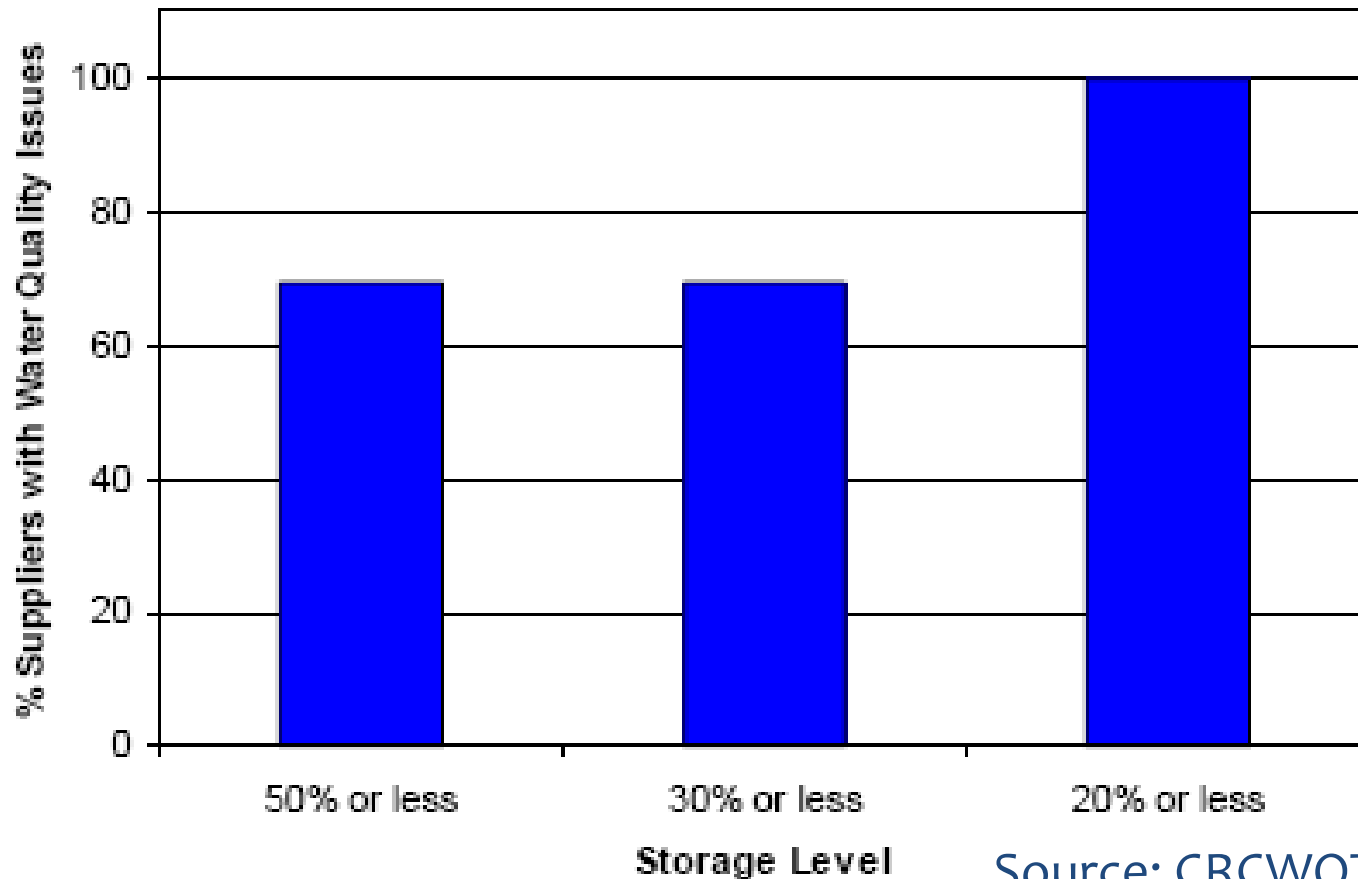
Drought & Shigellosis

$R^2 = 0.5393$
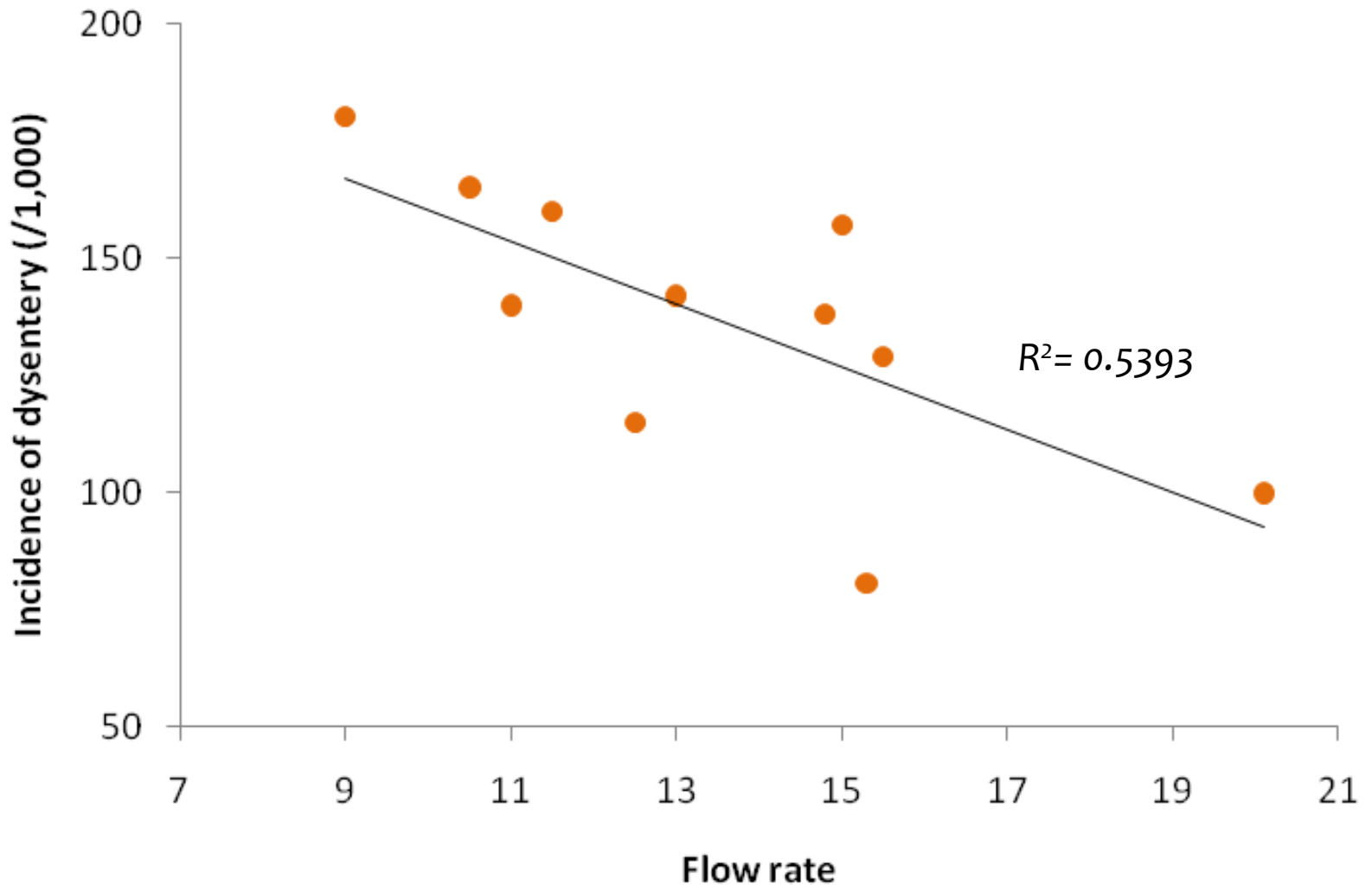
How climate & weather affects food- & water-borne disease: Sea level rise

Cities vulnerable to sea level rise

Source: Hallegatte et al. (2013) 37

India: Vulnerability to Sea Level rise

Vibrio spp.

- *Vibrio* are commonly estuarine & marine bacteria & include at least 12 known pathogens to humans
  - *V. vulnificus*
  - *V. parahaemolyticus*
  - *V. cholerae*

- In general, this group replicates easily in natural waters & biota, especially under high temperatures
 - Directly related to increasing water temperatures
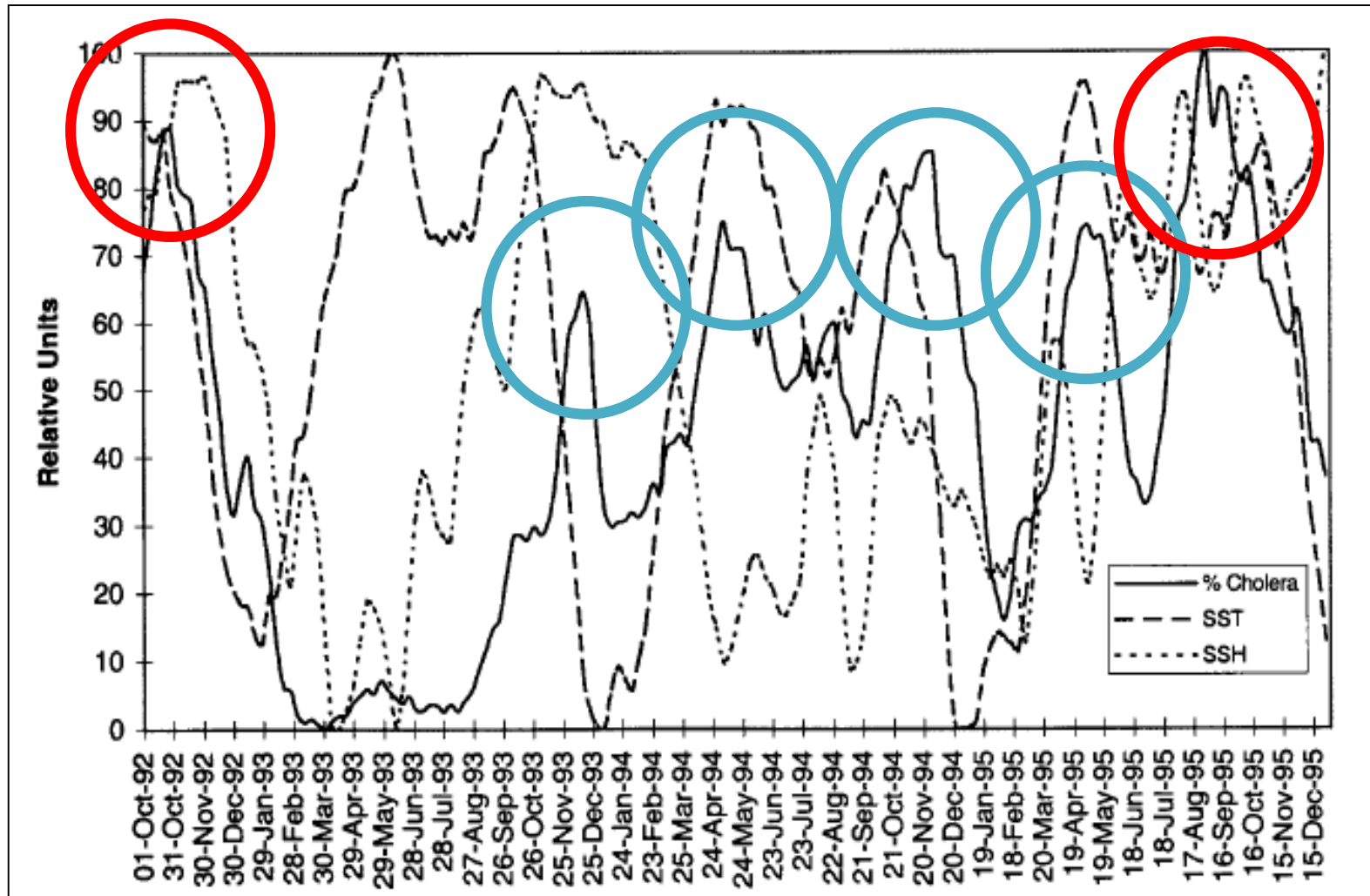
Cholera: South Asia

- Yearly epidemics correspond to natural environmental cycles & contamination
  - Influx of estuarine water
  - Plankton blooms
  - Monsoons
  - Warm temperatures
- Cycles can be modelled for year to year changes in outbreaks

Bay of Bengal: Sea surface height & sea surface temperature

Source: Lobitz et al. (2000) 41
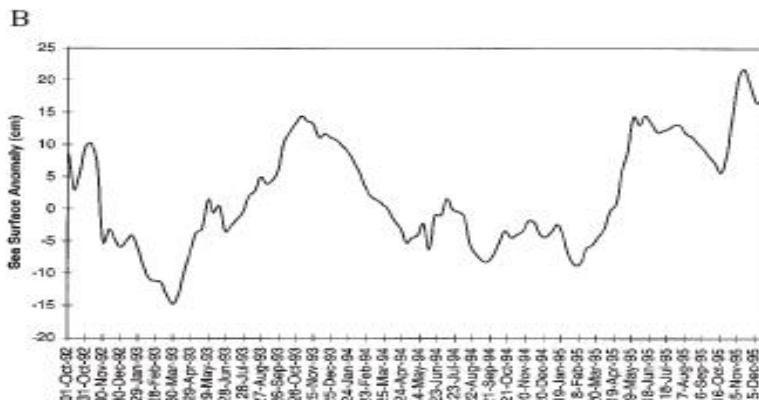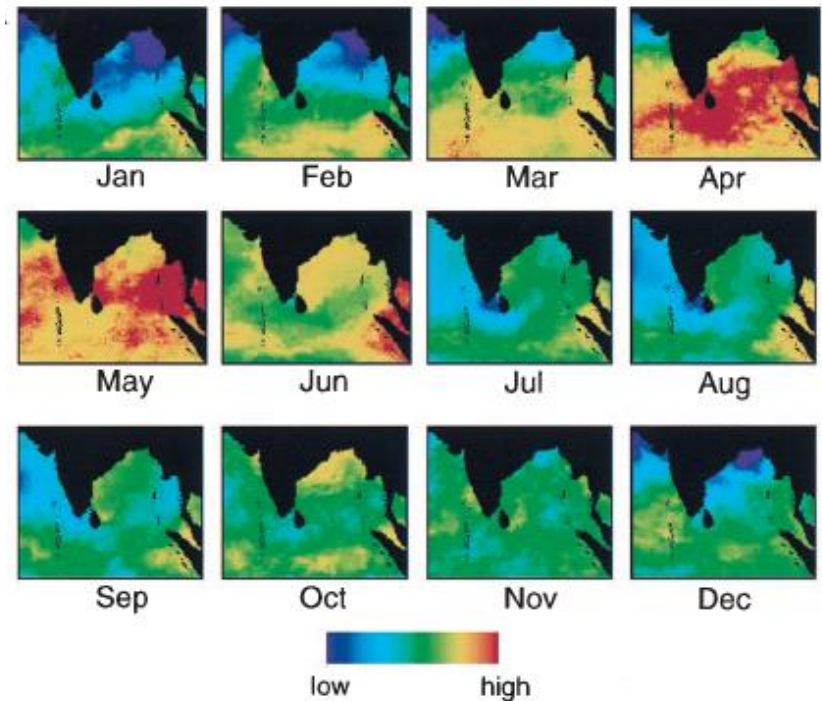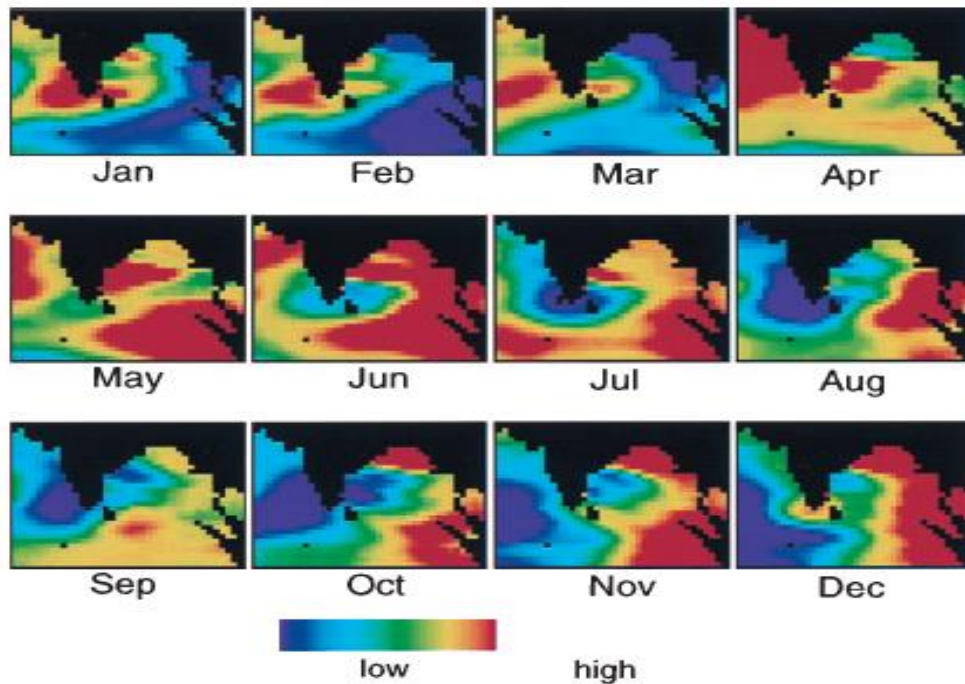
# Bay of Bengal: Cholera & sea surface height

Measures to address water- & food-borne diseases associated with climate change

Water-borne disease: summary

- Climate projections for increased warming & increased extreme events suggest water-borne diseases may increase

- Mitigation & adaptation will be enhanced by understanding the ecology of pathogens
  - What underlying factors provide the link to climate?
  - How do changing landscapes affect disease incidence under changing climate conditions?

The water tower of Asia
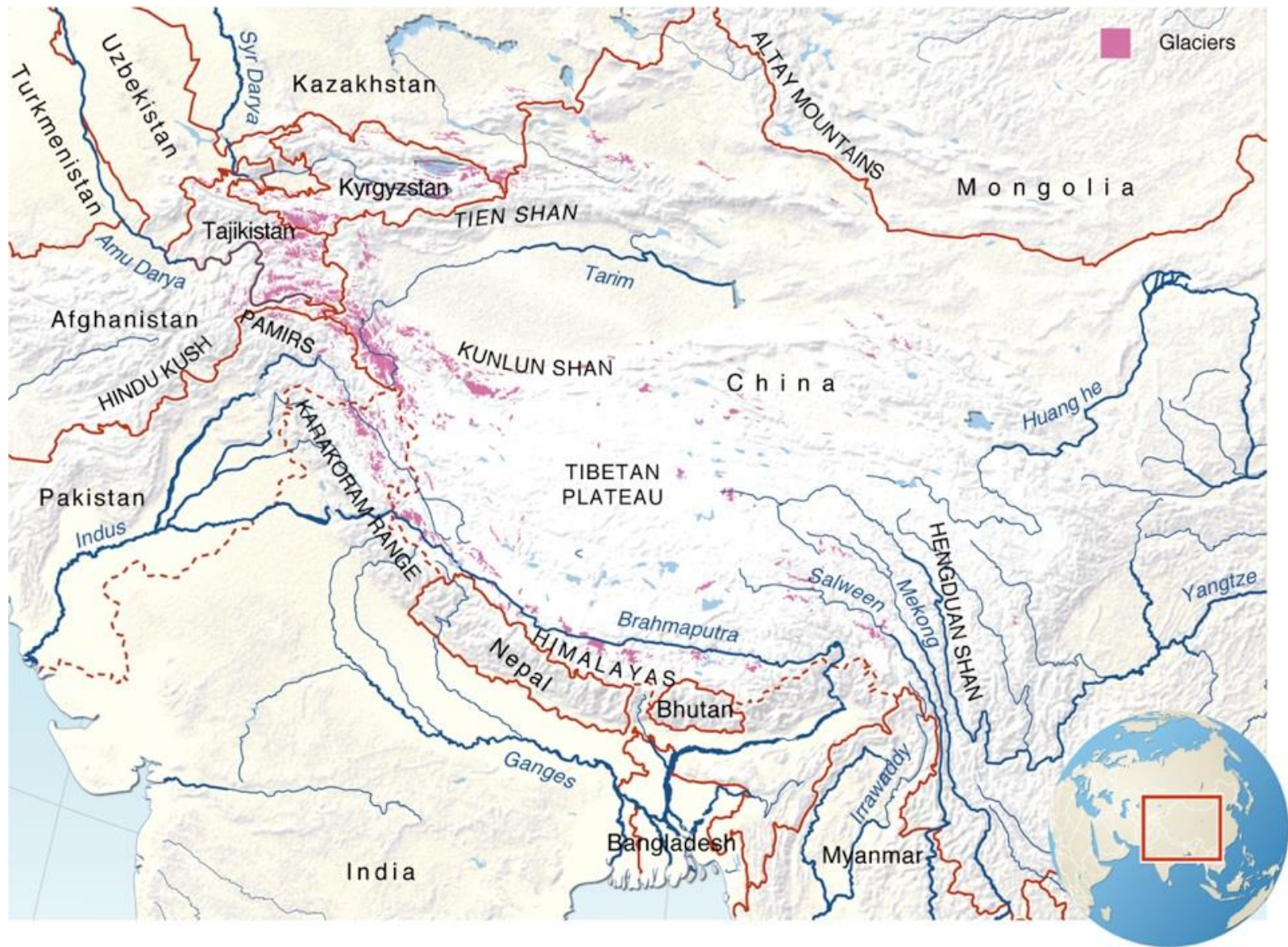
The water tower of Asia

River	Area sq km	Mean discharge (m³/s)	% of Glacier melt in river flow	Population x 1,000	Population density	Water per person m³/year
Indus	1,081,718	5,533	44.8	178,483	165	830
Ganges	1,016,124	18,691	9.1	407,466	401	~2500
Brahma	651,335	19,824	12.3	118,543	182	~2500
Irrawaddy	413,710	13,565	small	33,097	80	18,614
Salween	271,914	1,494	8.8	5,982	22	23,796
Mekong	805,604	11,048	6.6	57,198	71	8,934
Yangtze	1,722,193	34,000	18.5	368,549	214	2,265
Yellow	944,970	1,365	1.3	147,415	156	361
Tarim	1,152,448		40.2	8,067	7	754
Total				1,324,800		

Measures to address water- & food-borne diseases

- The effects of climate change on water & foodborne diseases can be mitigated
  - Focus on public health response
  - Focus on basic infrastructure
  - Increased attention to treatment options

- We have the tools to address problems & prevent disease

- Understanding how climate may increase risk can be used to prioritize adaptation or rapid response measures
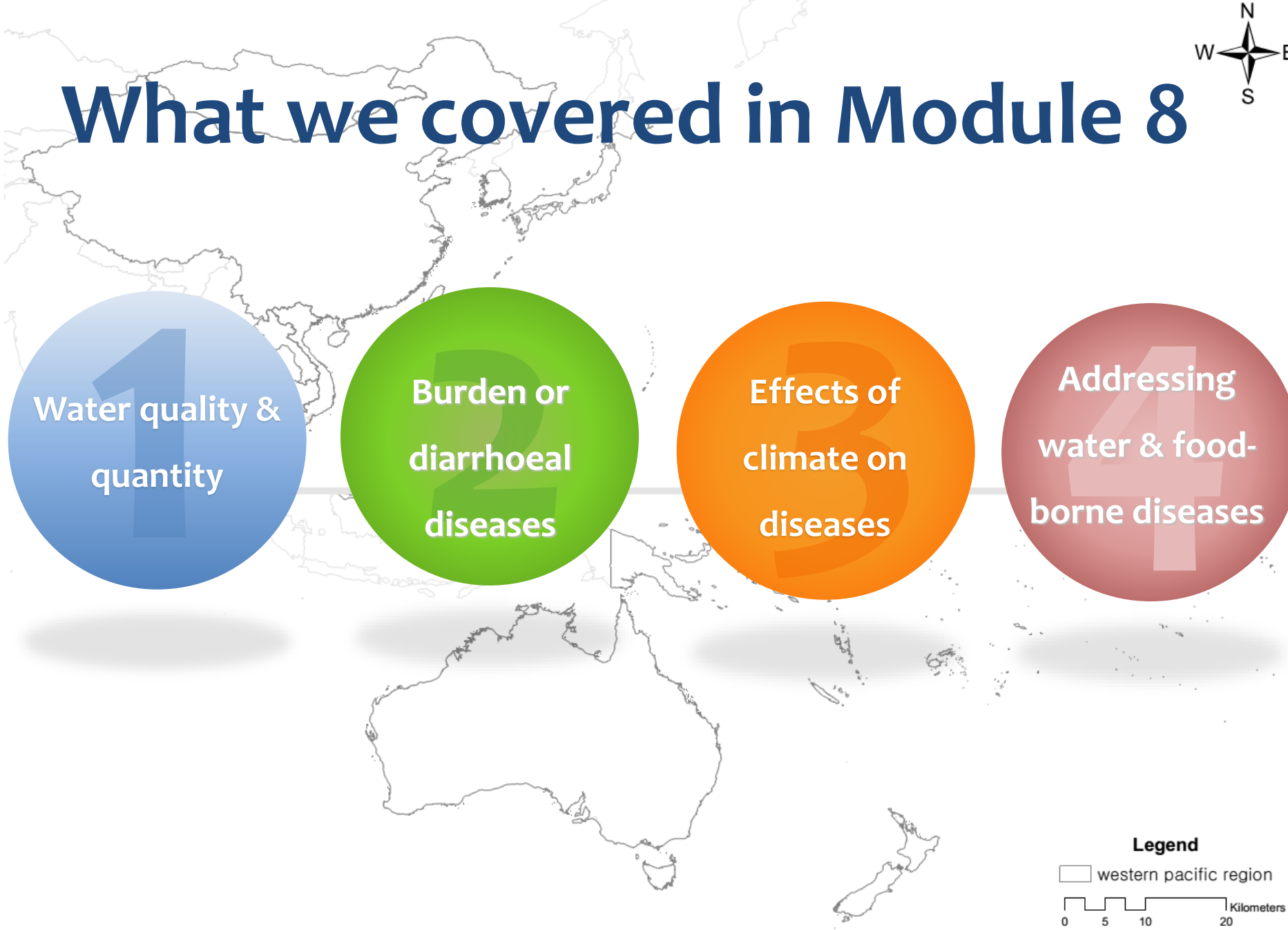
What we covered in Module 8
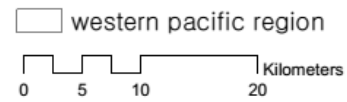
1 Water quality & quantity

2 Burden or diarrhoeal diseases

3 Effects of climate on diseases

4 Addressing water & food-borne diseases

Legend

☐ western pacific region

Kilometers
0   5   10   20

48

Key messages in Module 8

- Waterborne diseases are mostly transmitted by faecal-orally transmitted diseases

- Climate can influence waterborne diseases in different ways depending on the local environment & population

- Mitigation & adaptation will be enhanced by understanding the ecology of pathogens