Assessing Threats from Natural Disasters and Climate Change

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SEDAC

Why it matters

1. More people are living in harm's way
2. There are more harms on the way
3. The patterns are uneven, and surprising catastrophes are likely
4. There are no easy responses – it will take sustained, coordinated, focused effort

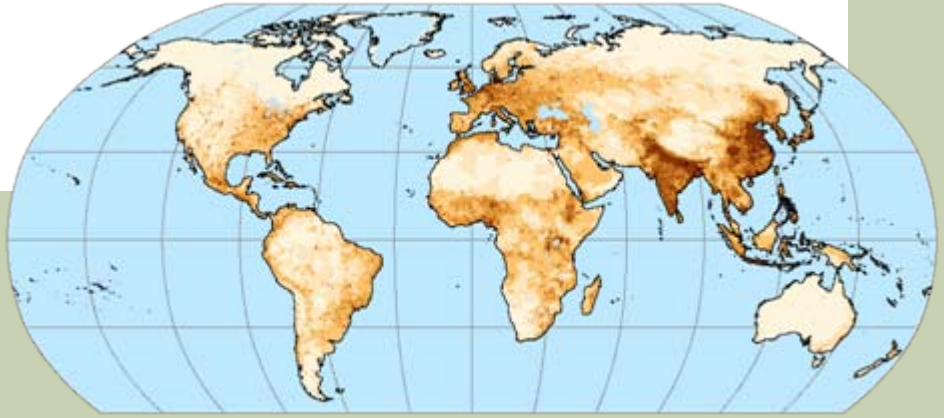
1) More People are Living in Harm's Way

Breakthroughs in how georeferenced data can be processed, integrated and analyzed make it possible to characterize natural disaster risks much more precisely than before

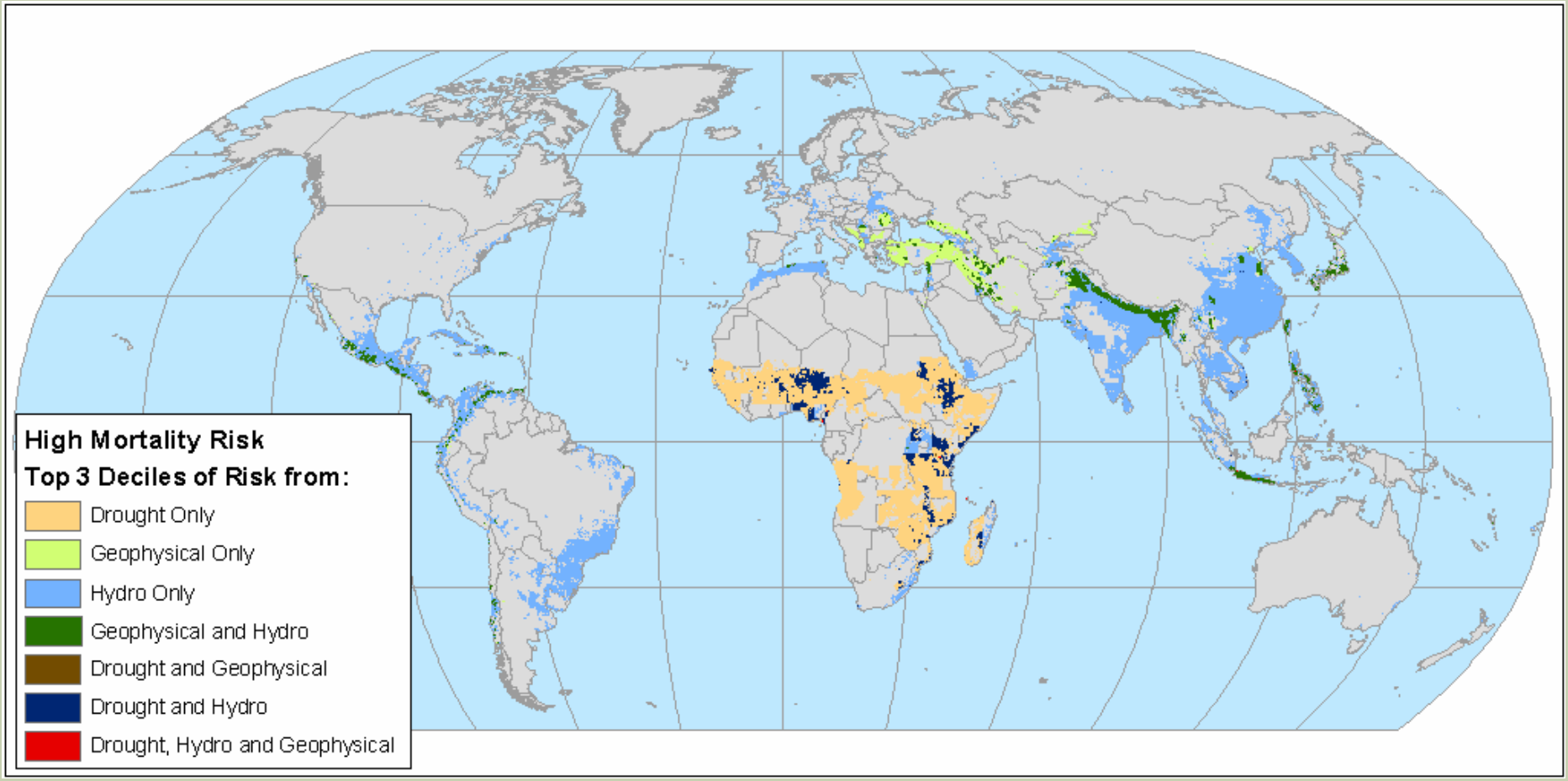
We try to focus on risks from multiple hazards

We try to focus on multiple impacts – disasters can affect

- **development**
- **conflict potential**
- **humanitarian crises**
- **public health**
- **migration**



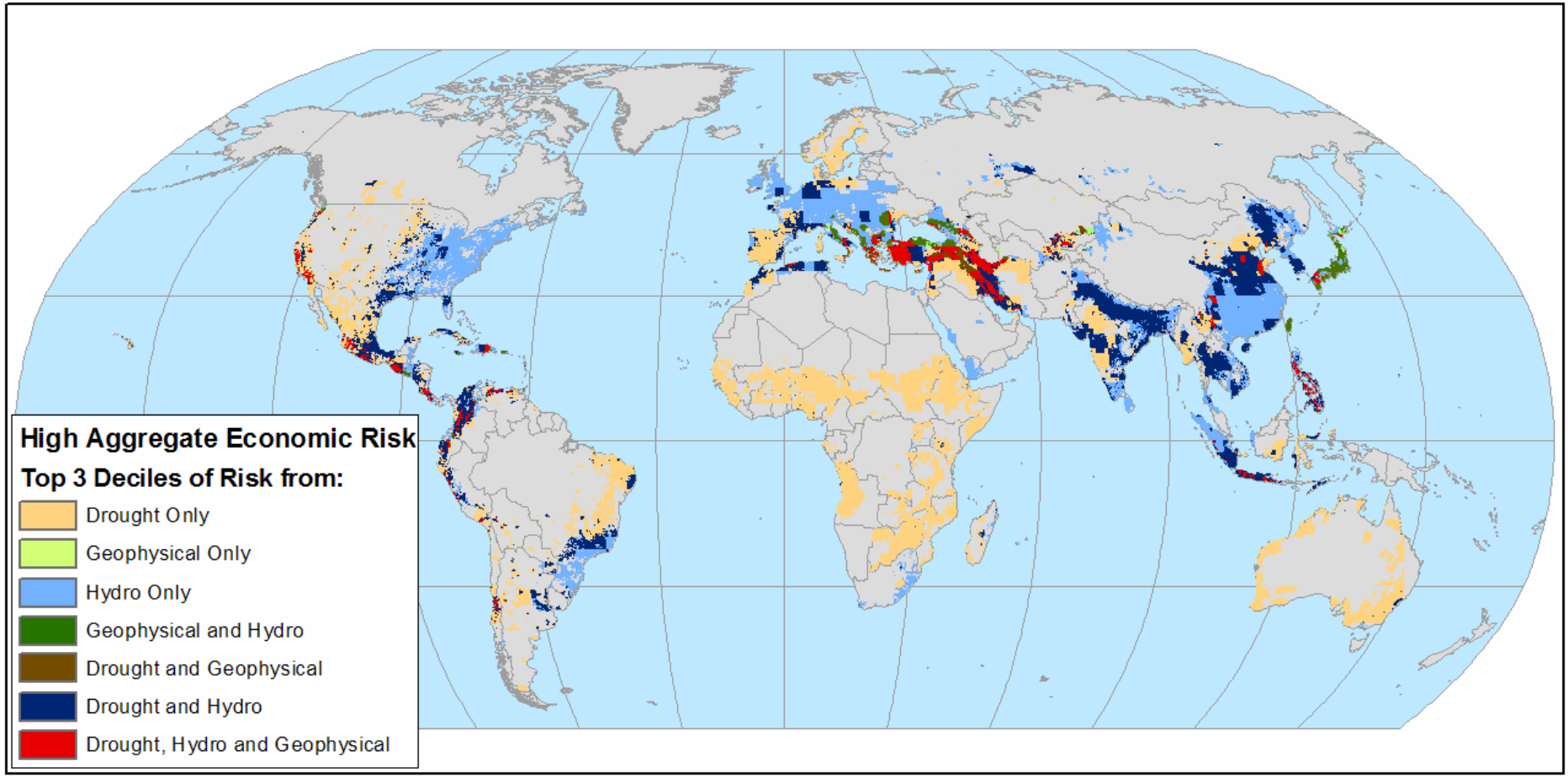
Global Natural Disaster "Hotspots" - Mortality



- Areas of high relative risk based on mortality

Hazards examined: drought, flood, landslides, earthquakes, volcanoes, cyclones

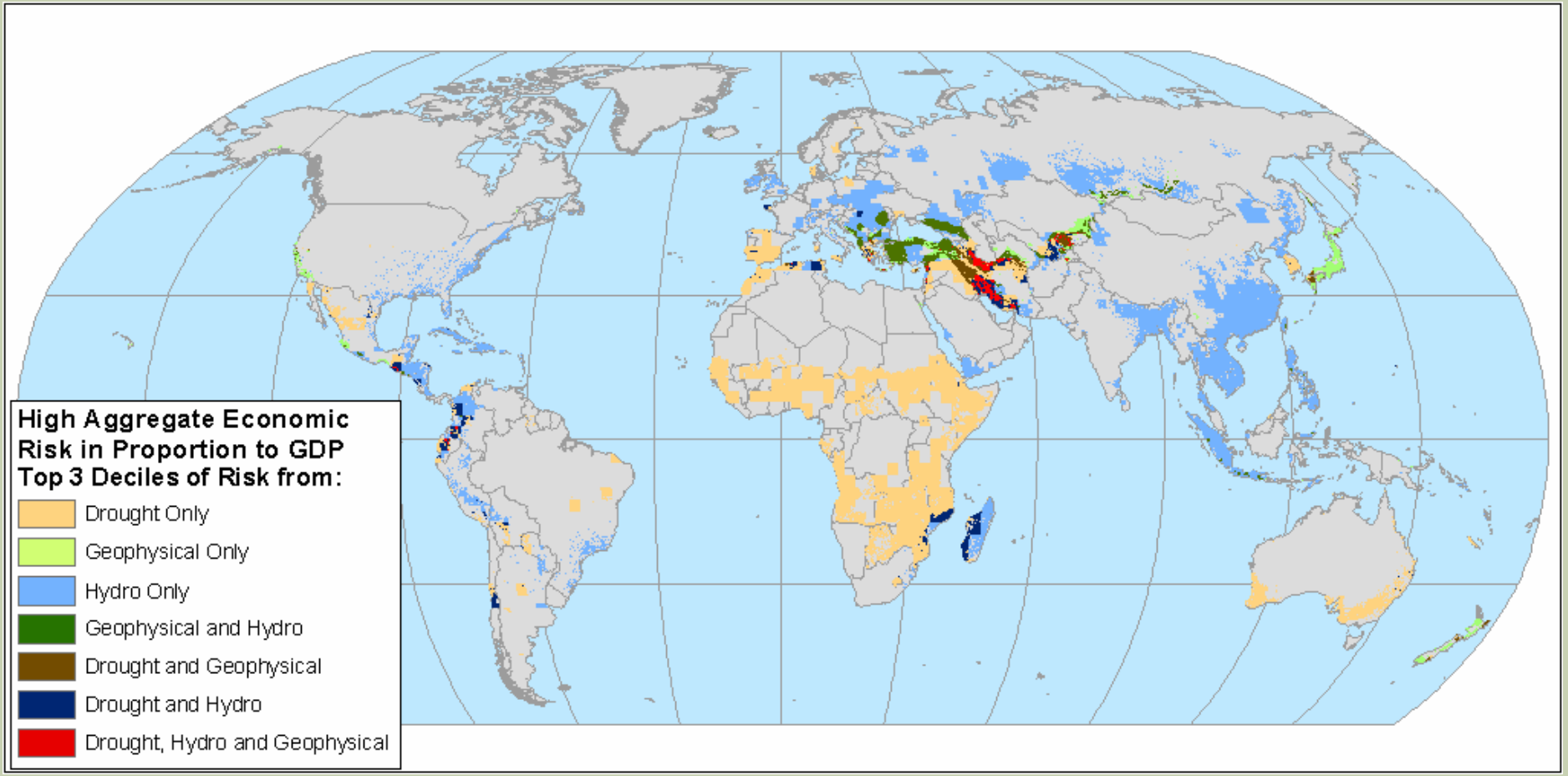
Global Natural Disaster "Hotspots" – Economic Losses



- Areas of high relative risk based on economic losses

Hazards examined: drought, flood, landslides, earthquakes, volcanoes, cyclones

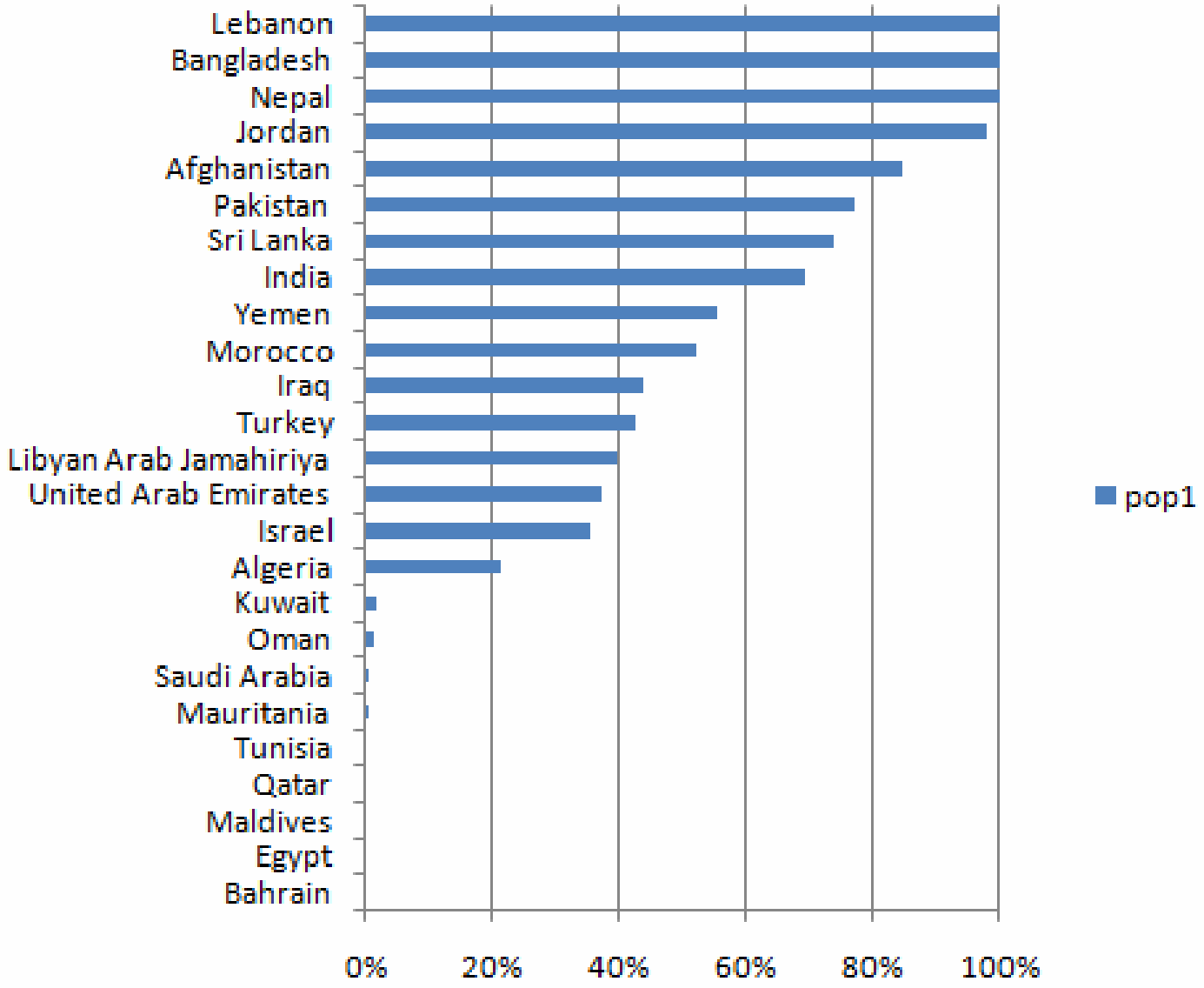
Global Natural Disaster “Hotspots” – Economic Losses Relative to GDP



- Areas of high relative risk based on economic losses as a proportion of GDP density

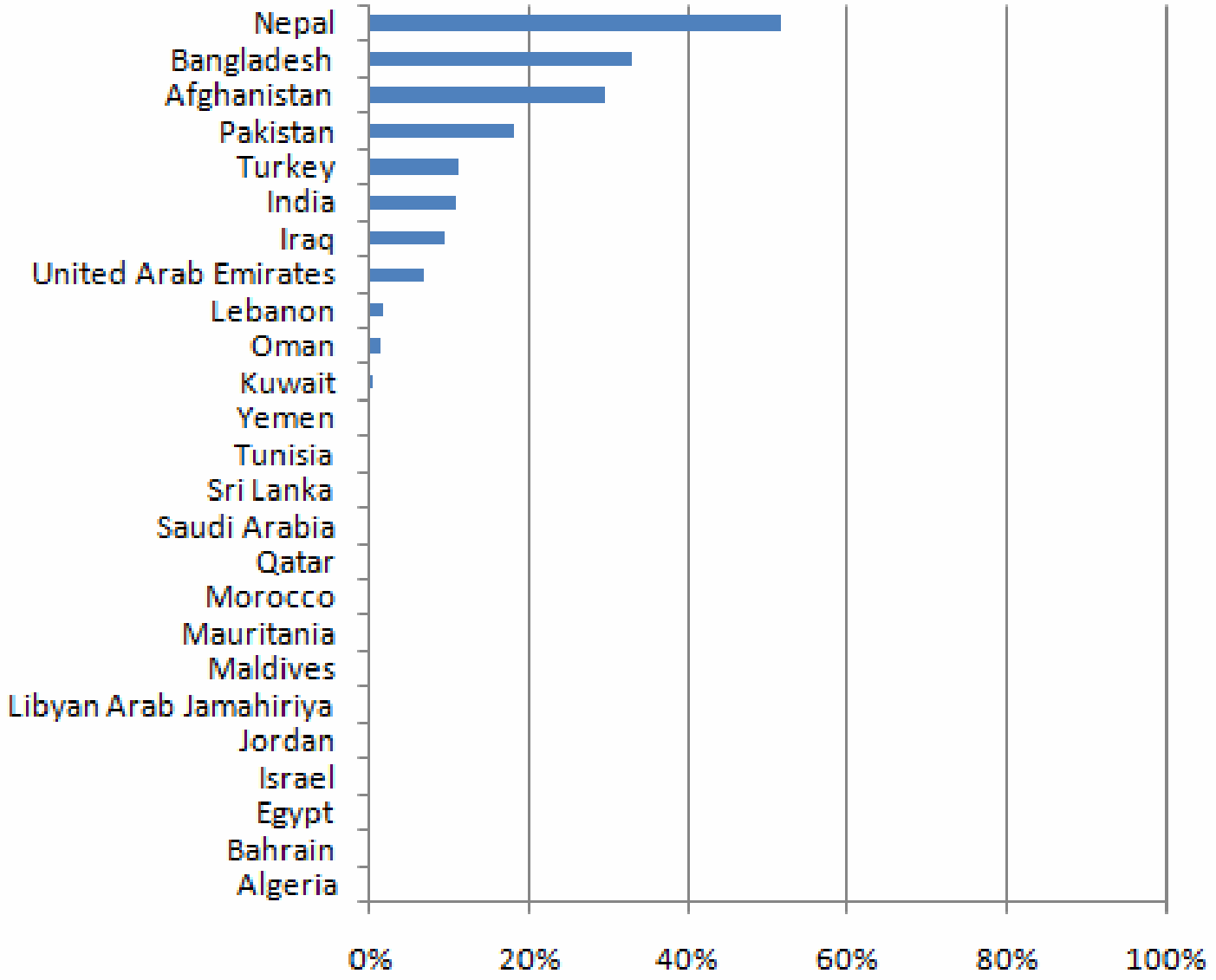
Hazards examined: drought, flood, landslides, earthquakes, volcanoes, cyclones

Percentage of Population in 1 Hazard Hotspot



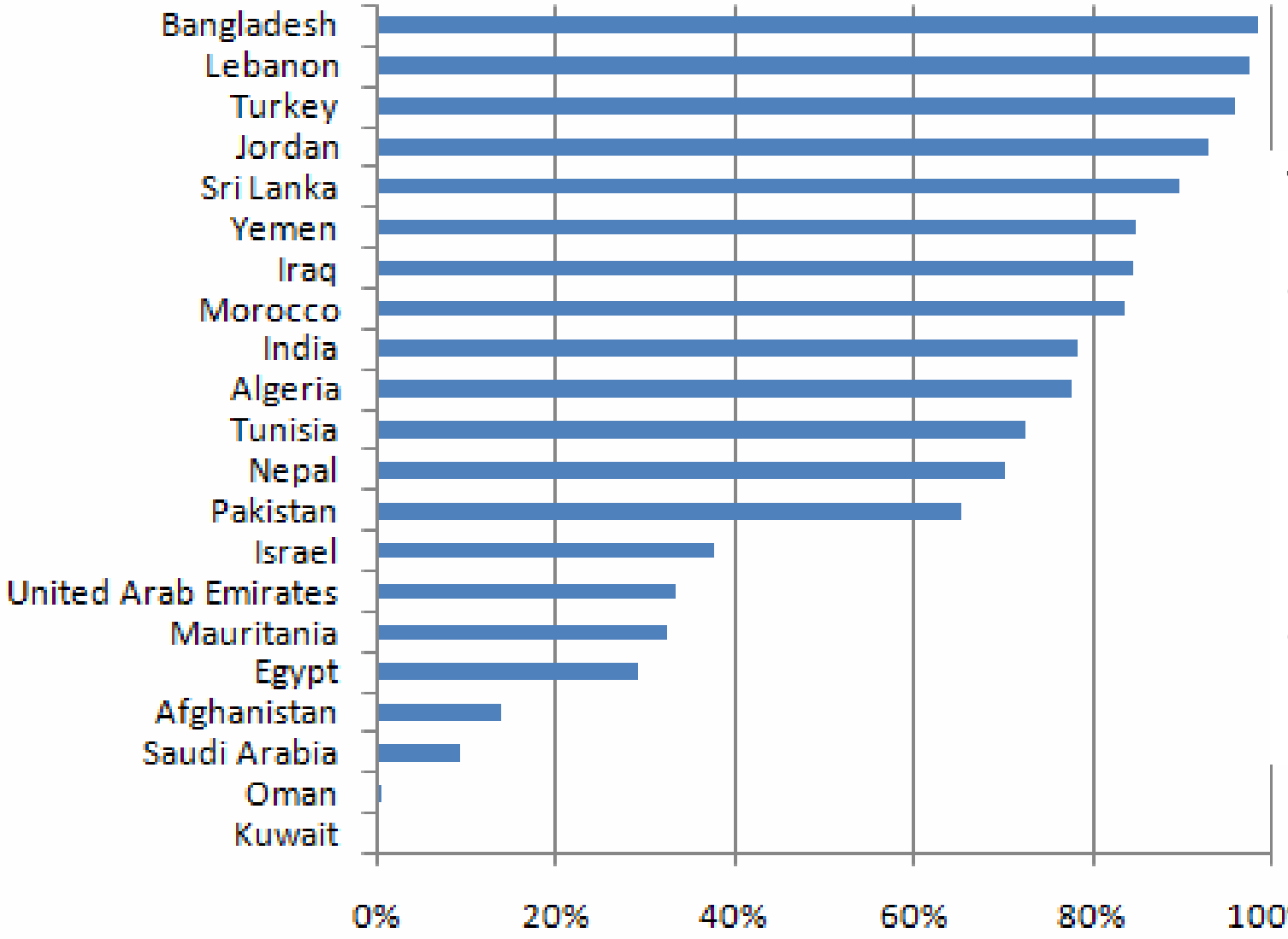
These hotspots are defined by locating places in highest 3 deciles, globally, of physical exposure

Percentage of Population in 2 Hazard Hotspots



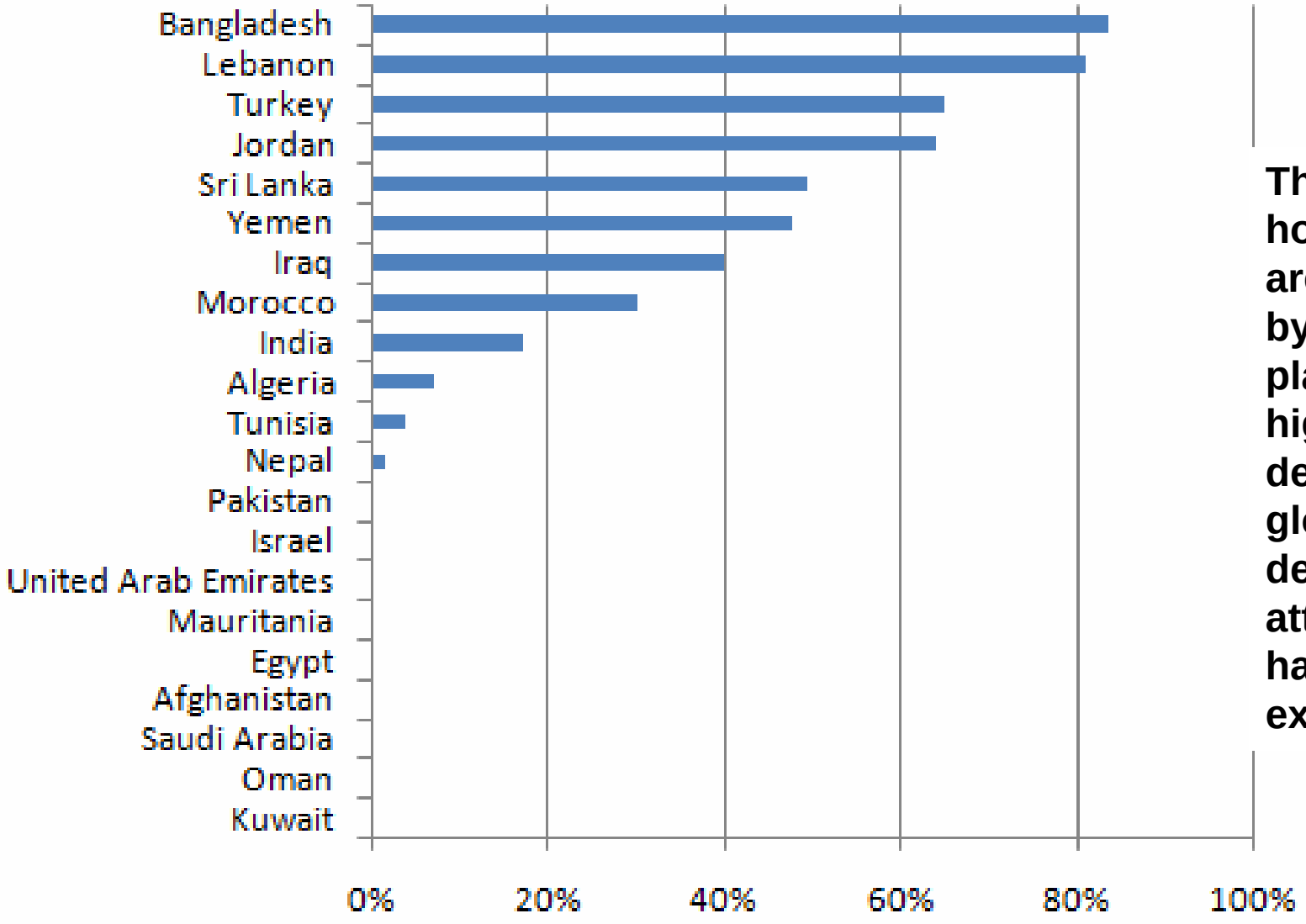
These hotspots are defined by locating places in highest 3 deciles, globally, of physical exposure

Percentage of Population Living in 1 or more Mortality Hotspots



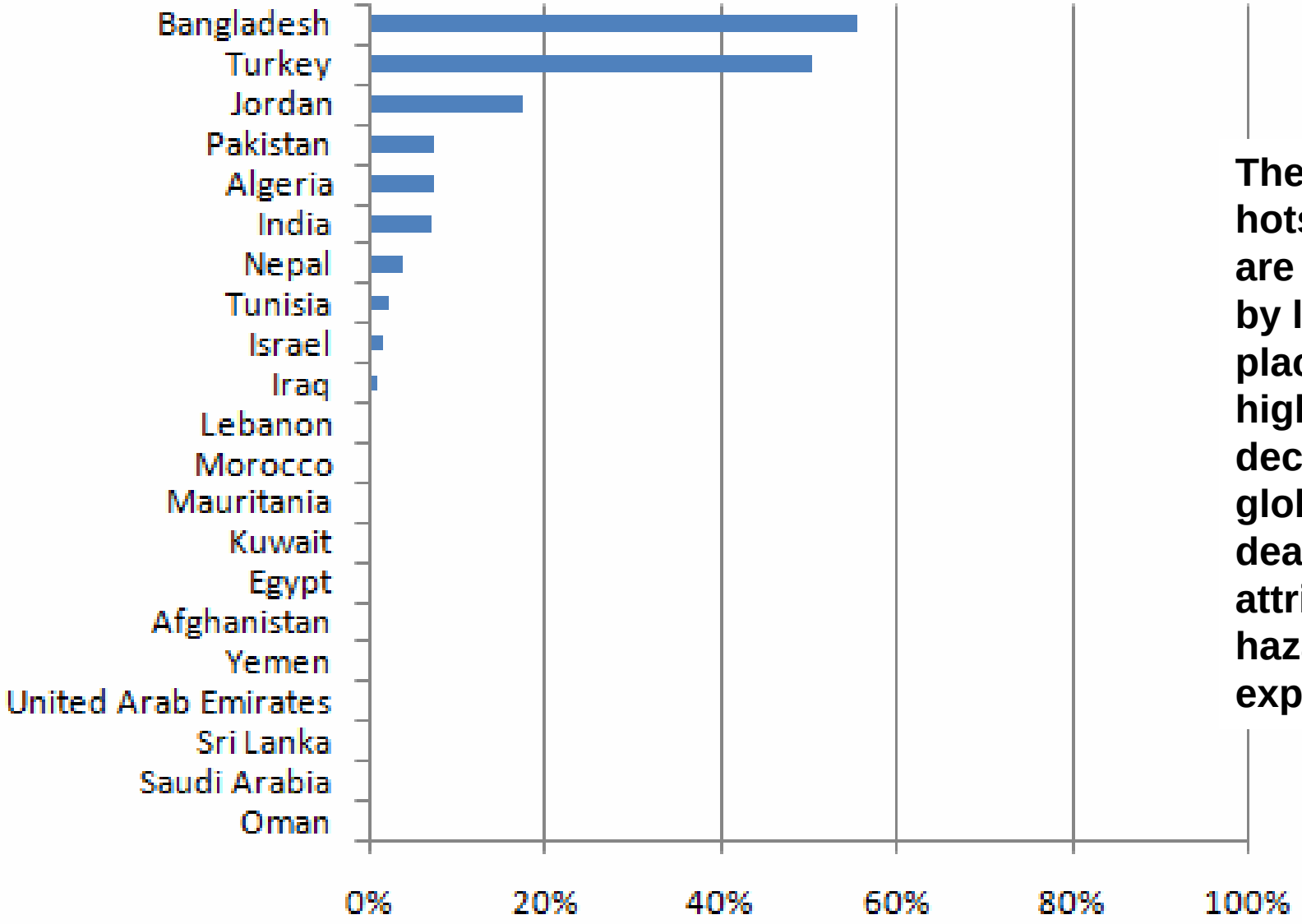
These hotspots are defined by locating places in highest 3 deciles, globally, of deaths attributed to hazard exposure

Percentage of Population Living in 2 or more Mortality Hotspots

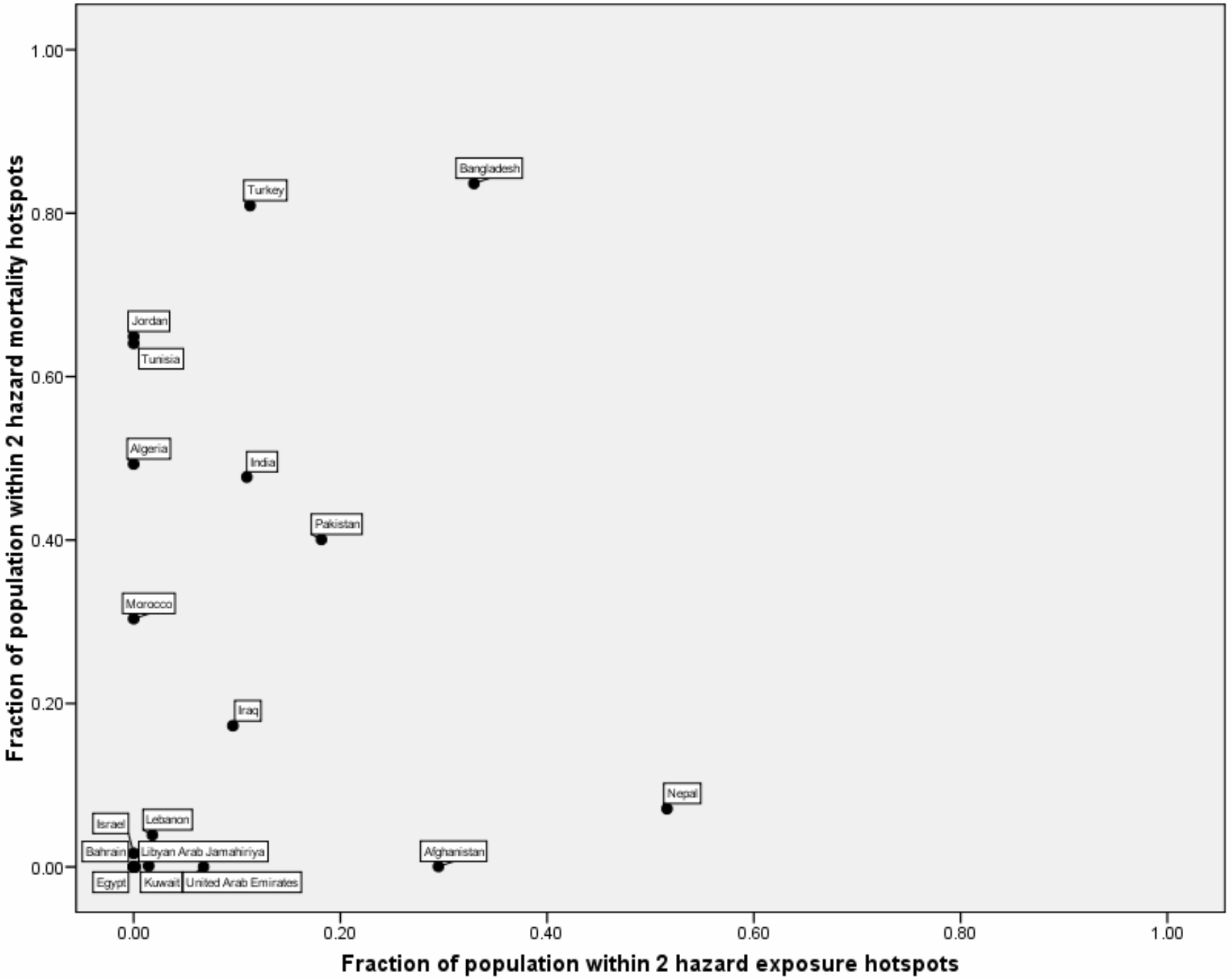


These hotspots are defined by locating places in highest 3 deciles, globally, of deaths attributed to hazard exposure

Percentage of Population Living in 3 or more Mortality Hotspots



These hotspots are defined by locating places in highest 3 deciles, globally, of deaths attributed to hazard exposure


Fraction of population within 2 hazard mortality hotspots
1.00
0.80
0.60
0.40
0.20
0.00
Bangladesh
Turkey
Jordan
Tunisia
Algeria
India
Pakistan
Morocco
Iraq
Nepal
Israel
Lebanon
Bahrain
Libyan Arab Jamahiriya
Afghanistan
Egypt
Kuwait
United Arab Emirates
0.00
0.20
0.40
0.60
0.80
1.00
Fraction of population within 2 hazard exposure hotspots

2) There are more harms on the way

Global change is underway on unprecedented scale

It's more than just climate change – multiple stresses threaten ecological and social systems

These changes will alter historical patterns of some natural disasters – including floods, droughts, landslides, cyclones

Atmosphere

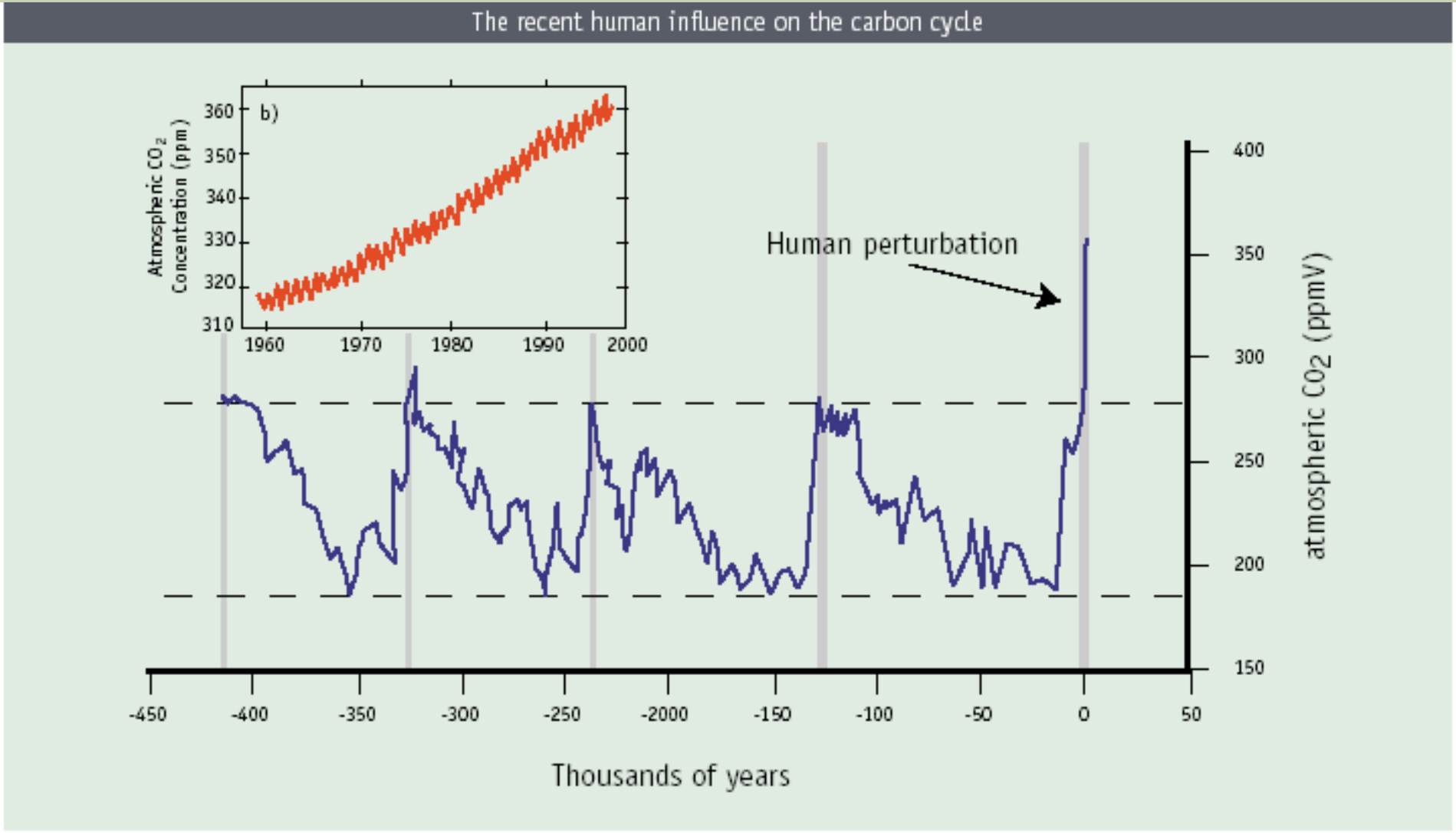
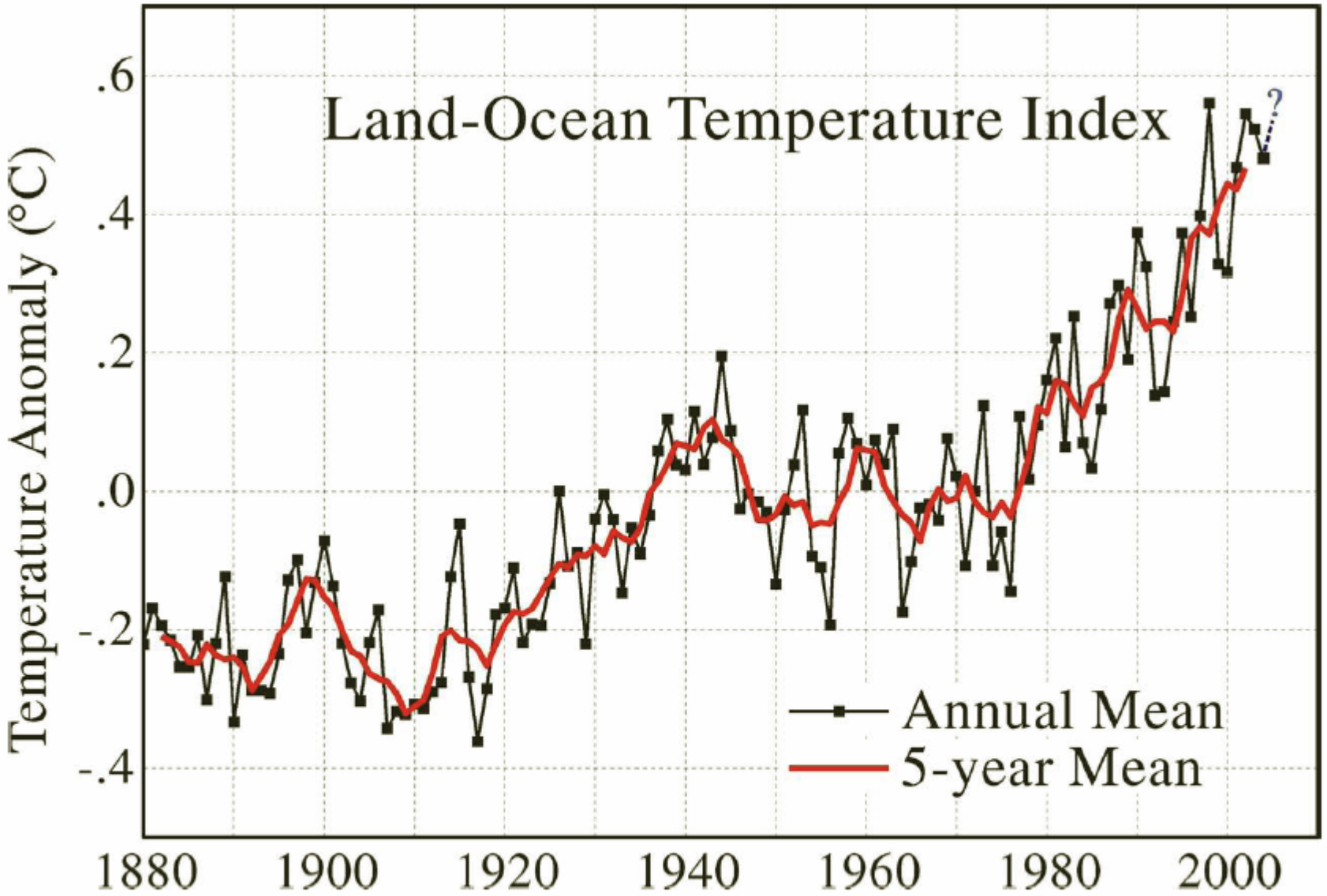


Figure 2 Atmospheric CO_2 concentration from the Vostok ice core record with the recent human perturbation superimposed. The inset shows the observed contemporary increase in atmospheric CO_2 concentration from the Mauna Loa (Hawaii) Observatory.

Sources: Petit et al. (1999) Nature 399, 429-436 and National Oceanic and Atmospheric Administration (NOAA), USA



Global mean surface temperature change based on surface air measurements over land and SSTs over ocean

Source: Update of Hansen et al., *JGR,* **106**, 23947, 2001; Reynolds and Smith, *J. Climate,* **7**, 1994; Rayner et al., *JGR,* **108**, 2003.

Slide courtesy James Hansen

Surface Melt on Greenland

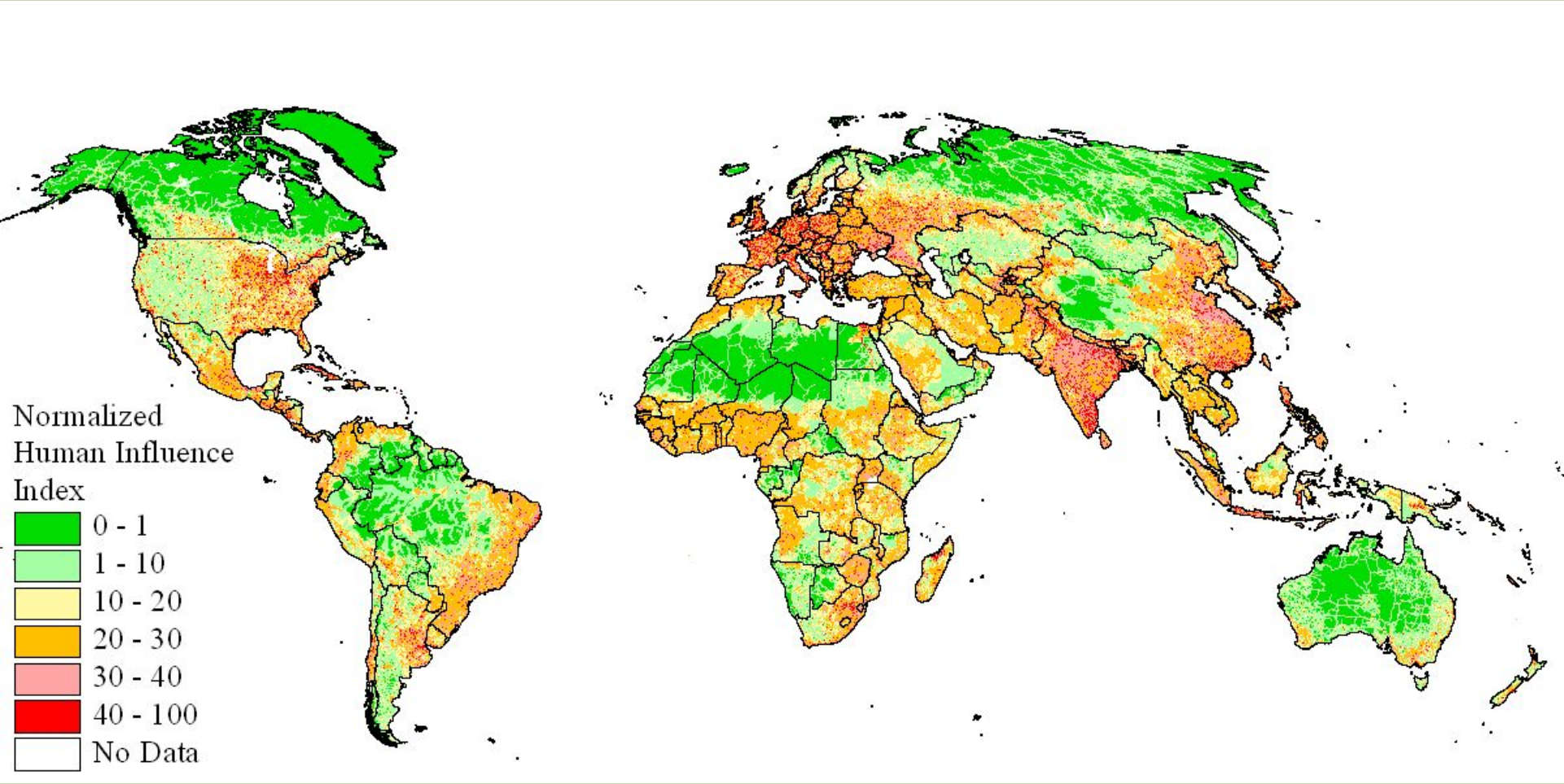
Melt descending into a moulin, a vertical shaft carrying water to ice sheet base.

Source: Roger Braithwaite, University of Manchester (UK). Slide courtesy James Hansen

Jakobshavn Ice Stream in Greenland

Discharge from major Greenland ice streams is accelerating markedly.

Source: Prof. Konrad Steffen, Univ. of Colorado. Slide courtesy James Hansen

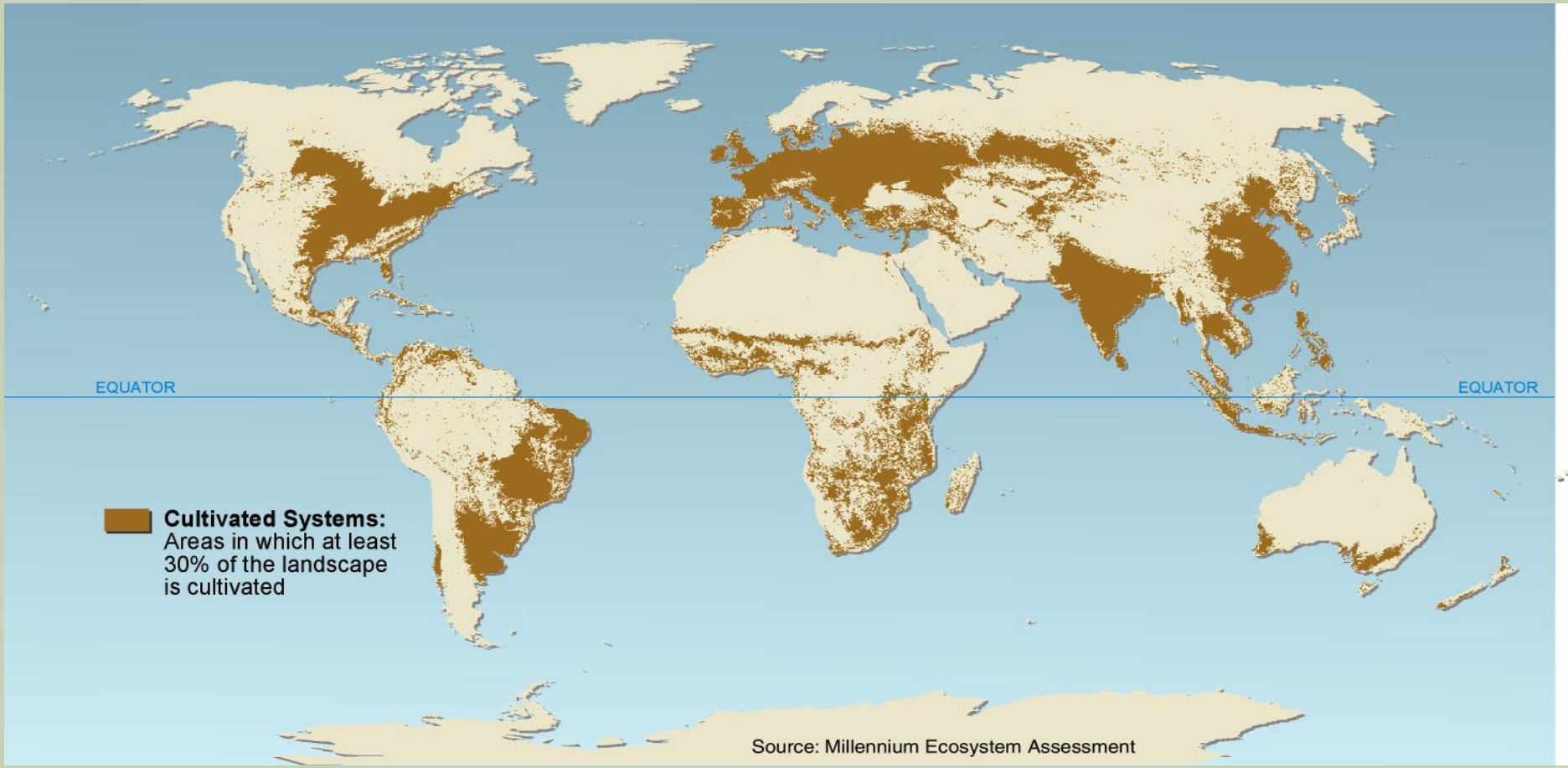


~80% of world's land surface has been significantly altered by direct human transformation

~40% of all photosynthesis appropriate by humans

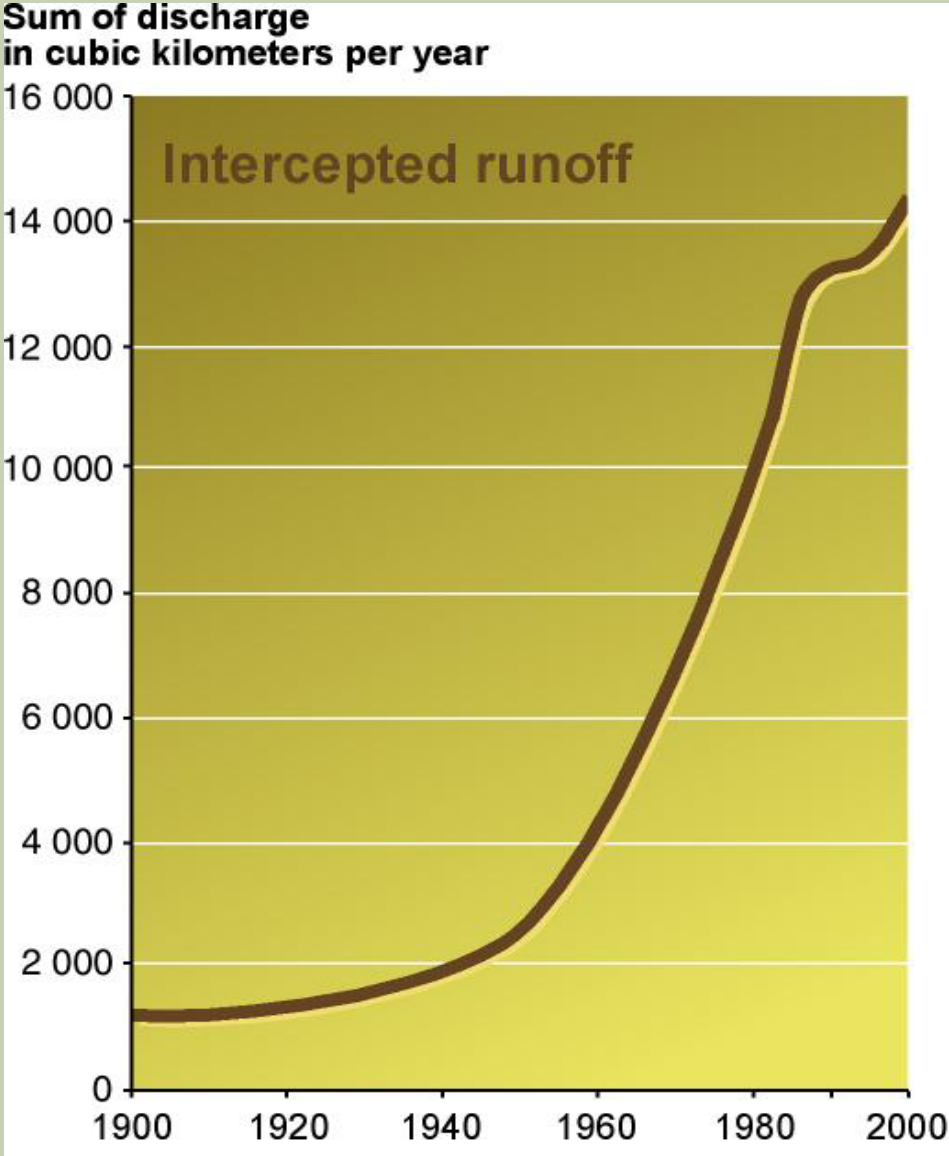
Unprecedented change in structure and function of ecosystems

More land was converted to cropland since 1945 than in the 18th and 19th centuries combined



Unprecedented change: Aquatic Ecosystems

- Amount of water in reservoirs quadrupled since 1960
- Withdrawals from rivers and lakes doubled since 1960

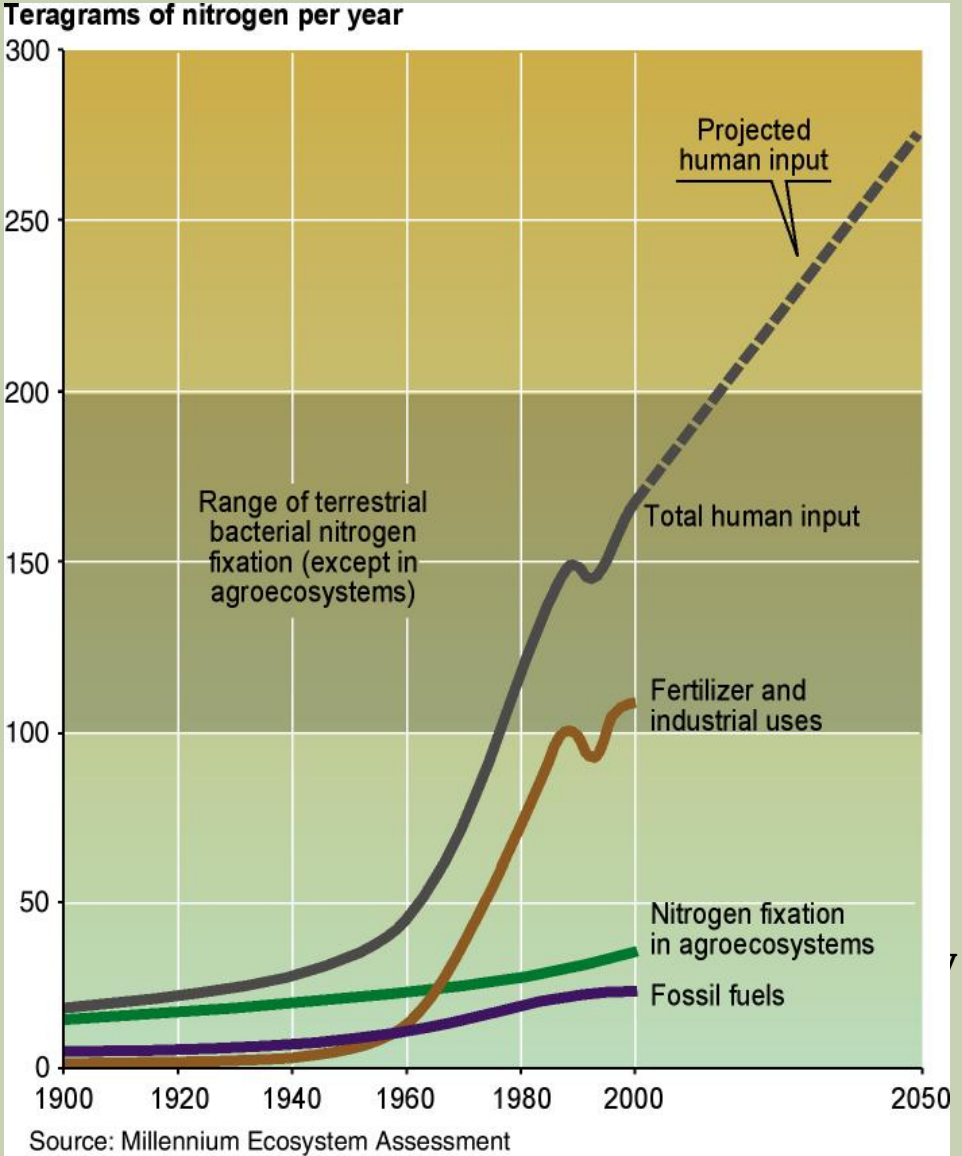


Unprecedented change: Biogeochemical Cycles

Since 1960:

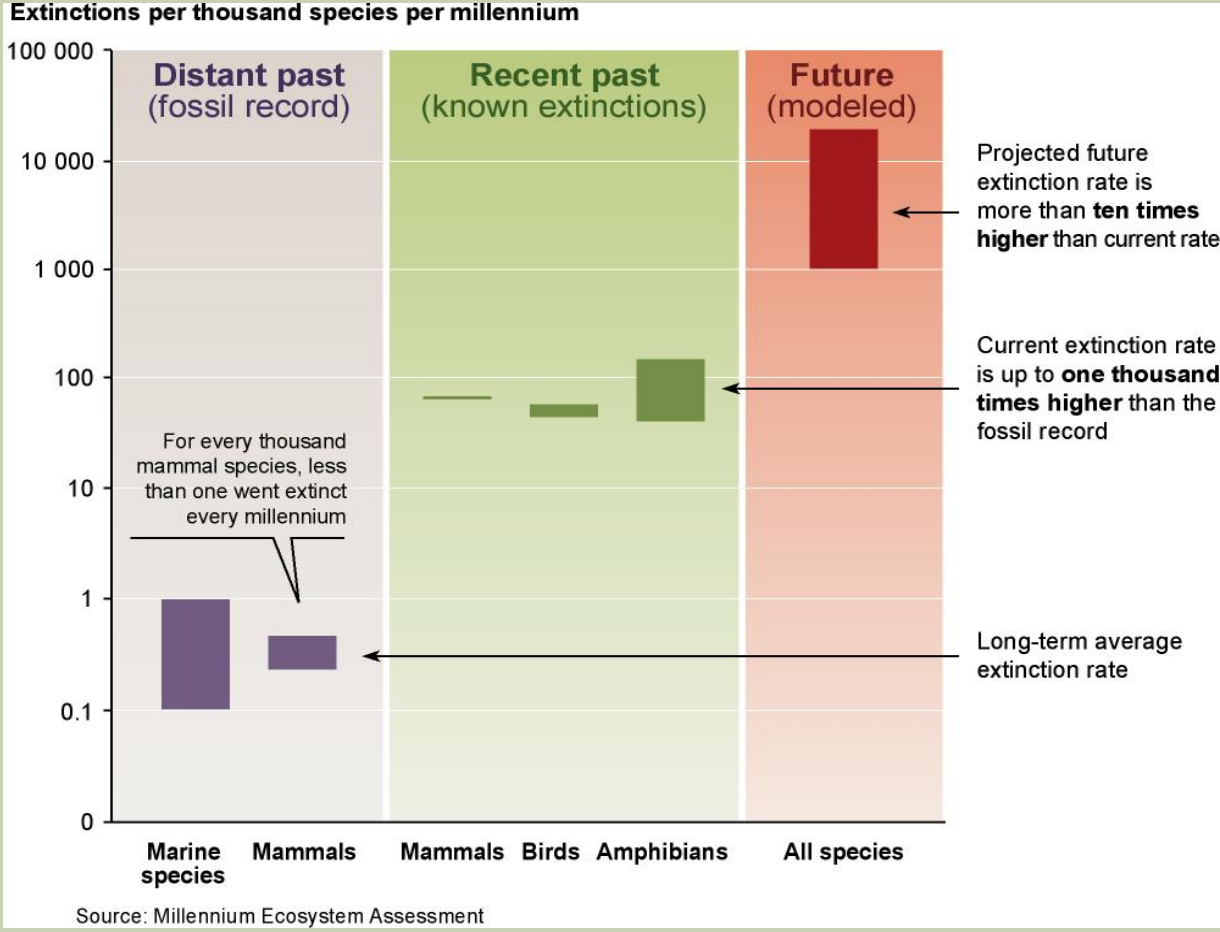
- Flows of biologically available nitrogen in terrestrial ecosystems doubled
- Flows of phosphorus tripled

> 50% of all the synthetic nitrogen fertilizer ever used has been used since 1985



Significant and largely irreversible changes to species diversity

- Humans have increased the species extinction rate by as much as 1,000 times over background rates typical over the planet's history
- 10–30% of mammal, bird, and amphibian species are currently threatened with extinction



Geographic extent of maximum fish catch

Source: Daniel Pauly, University of British Columbia)

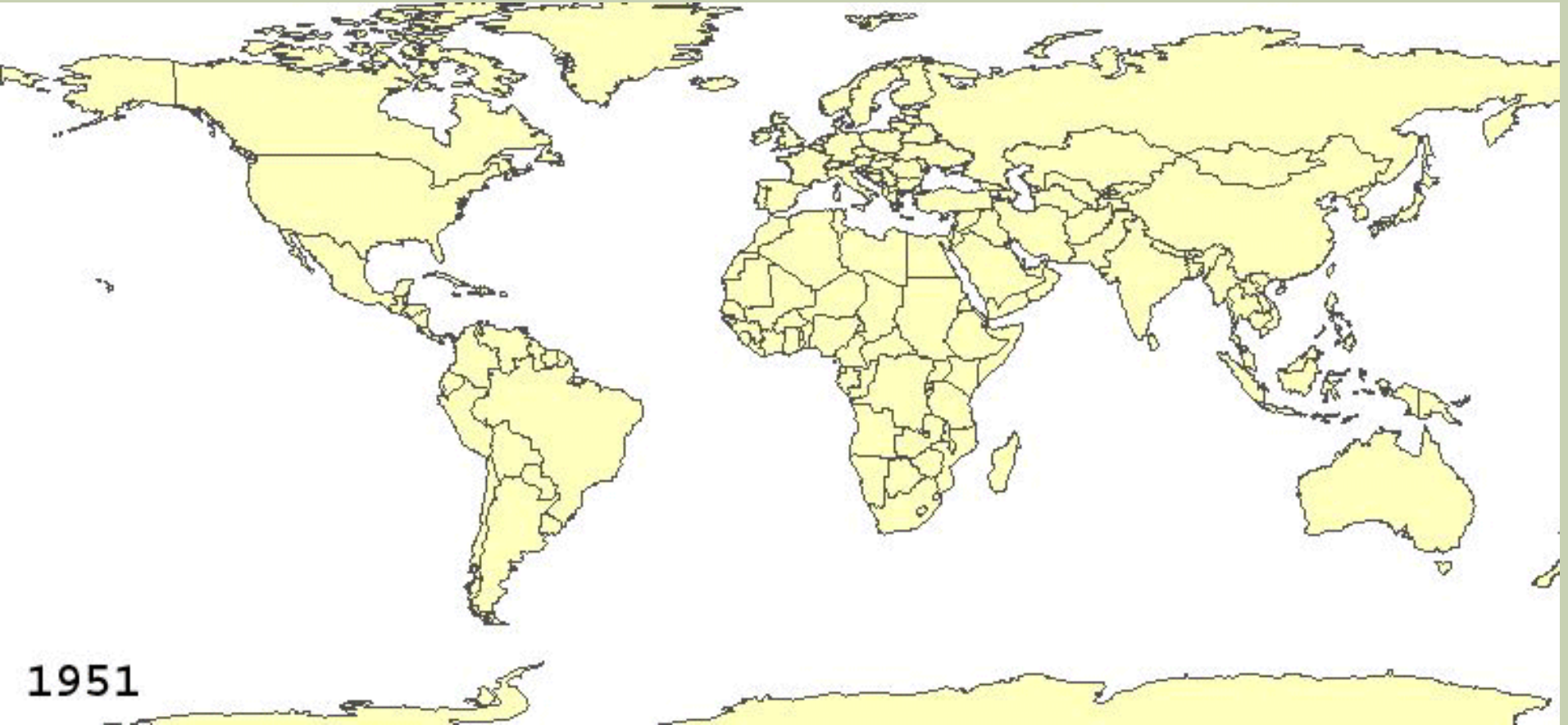
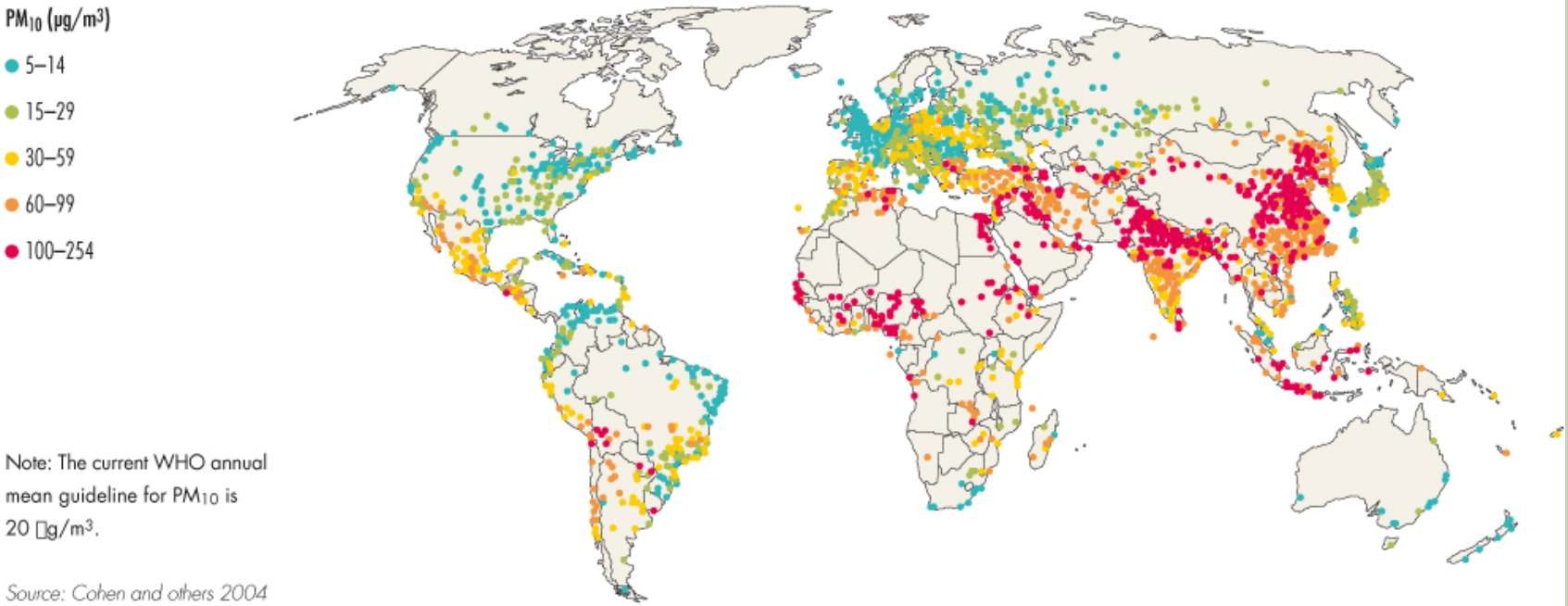


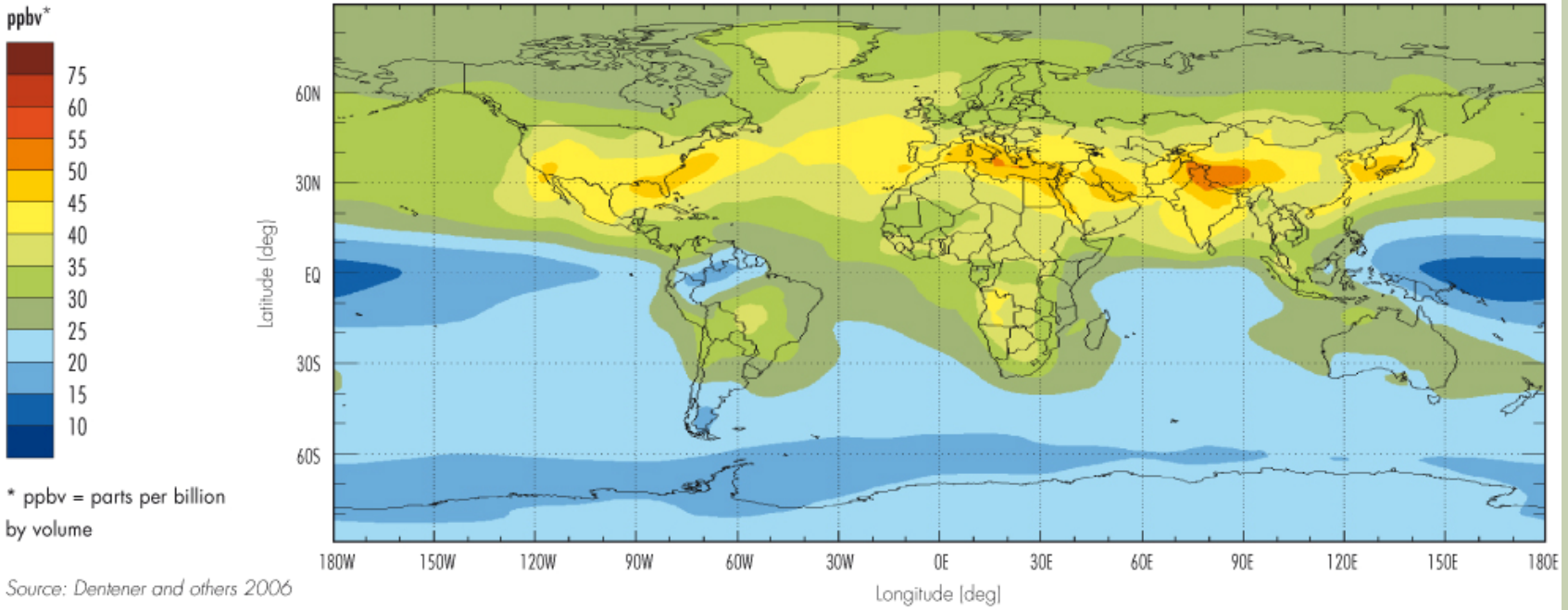
Figure 2.10 Estimated annual average concentrations of PM_{10} in cities with populations greater than 100 000, and in national capitals, for 1999



Note: The current WHO annual mean guideline for PM_{10} is 20 μg/m³.

Source: Cohen and others 2004

Figure 2.11 Calculated annual average tropospheric ozone concentrations in 2000 obtained by combining the outputs of several models

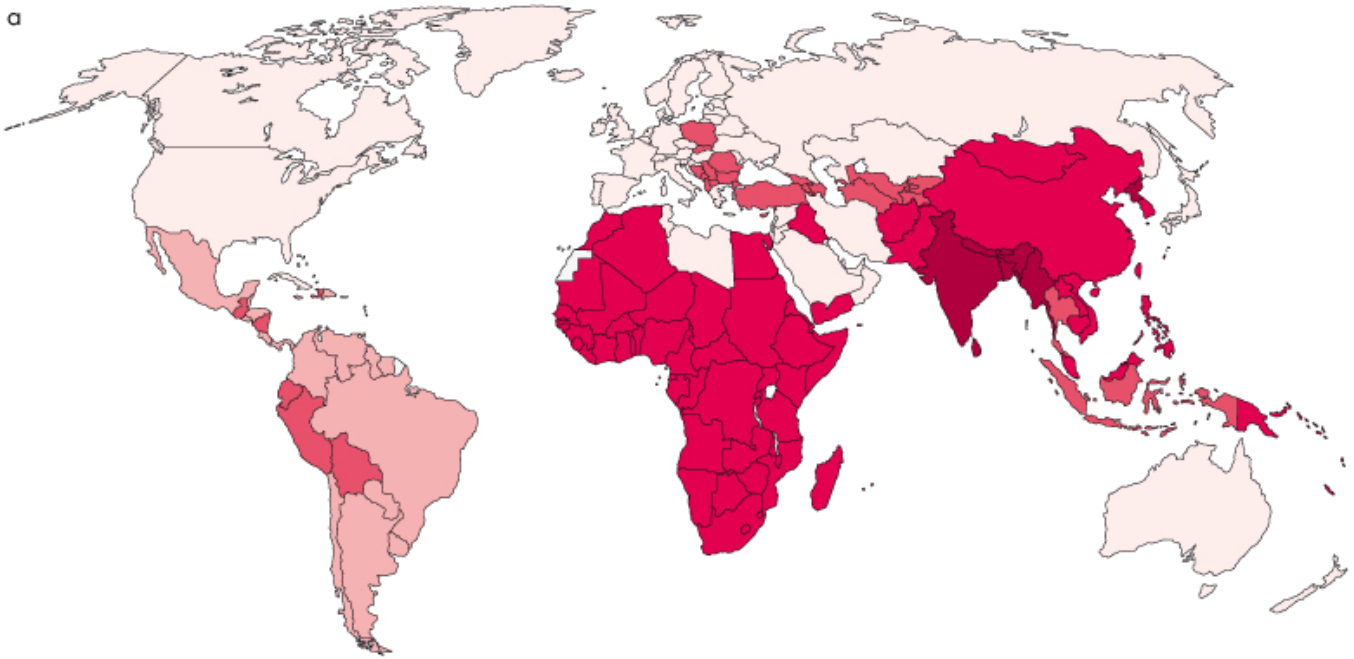


* ppbv = parts per billion by volume

Source: Dentener and others 2006

Figure 2.12 Global estimates of disease attributed to (a) indoor and (b) urban PM_{10} pollution, measured in DALYs

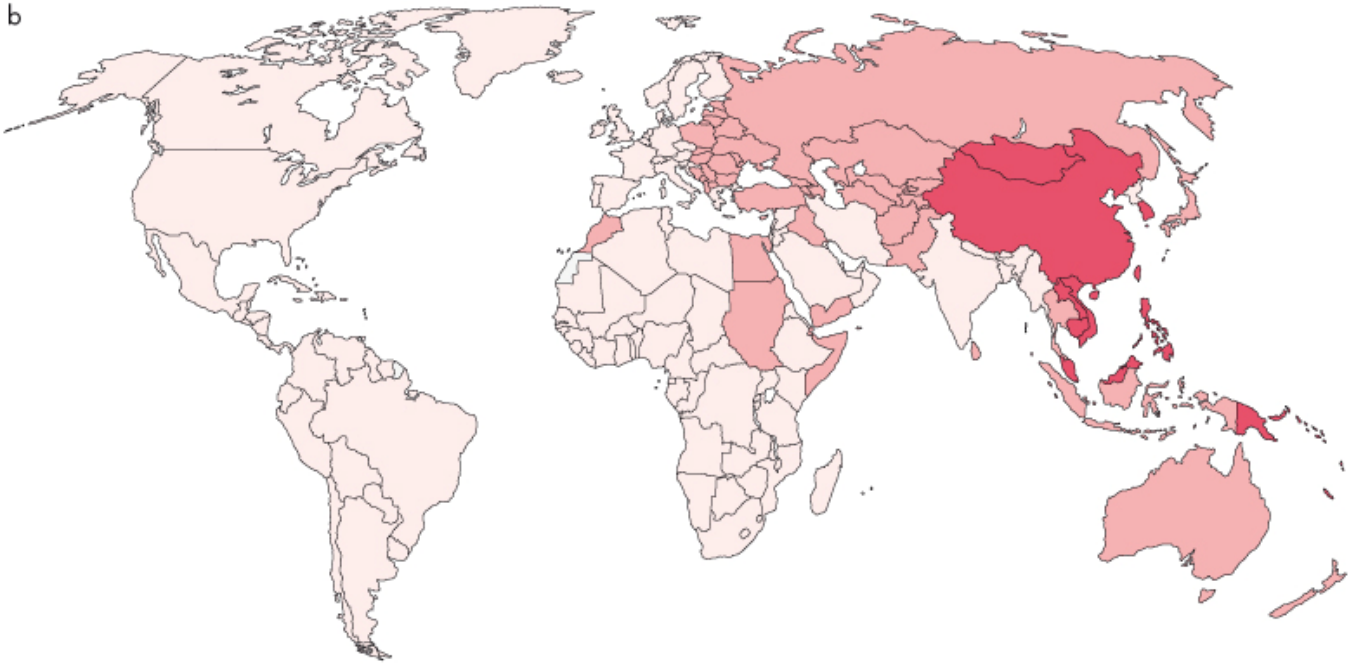
a



Proportion of DALYs attributable to indoor air pollution

- <0.5%
- 0.5–0.9%
- 1–1.9%
- 2–3.9%
- 4–7.9%

b



Proportion of DALYs attributable to urban PM_{10} pollution

- <0.5%
- 0.5–0.9%
- 1–1.9%

Notes: DALYs – Disability Adjusted Life Years. One DALY is equivalent to the loss of one year of healthy life. This is the only quantitative indicator of burden of disease that reflects the total amount of healthy life lost to all causes, whether from premature mortality or from some degree of disability.

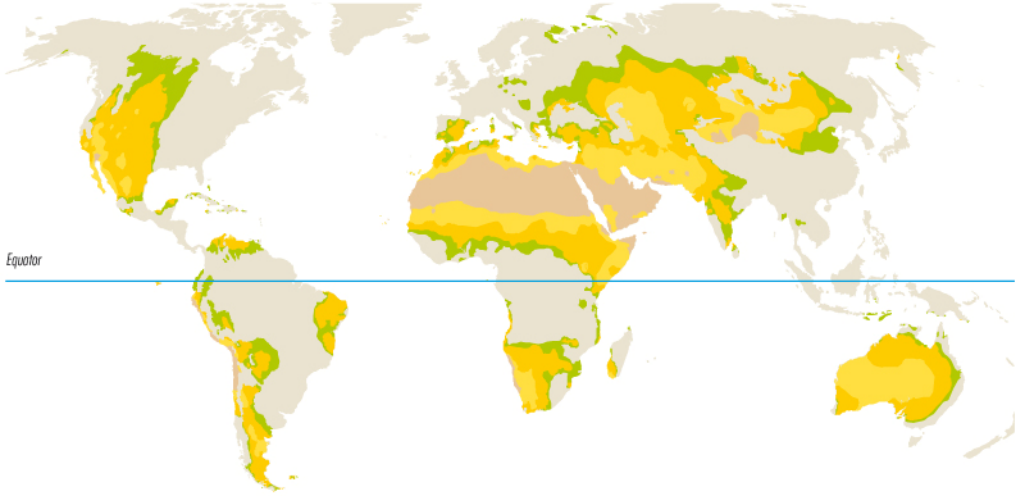
Source: WHO 2002

Figure 2.13 The impact of local air pollution on the growth of wheat in suburban Lahore, Pakistan

Note: The plants in the centre and on the right were both grown in local air, while the plant on the left was grown in filtered air. The effect of filtering the polluted air increased grain yield by about 40 per cent.

Credit: A. Wahid

Figure 3.9 Drylands – defined by the long-term mean of the ratio of annual precipitation to potential evapotranspiration



Hyper-arid
Arid
Semi-arid
Dry sub-humid

Note: Drylands include hyper-arid areas, while the definition of desertification relates to arid, semi-arid and dry sub-humid areas only (excluding hyper-arid), sometimes also referred to as "susceptible drylands."

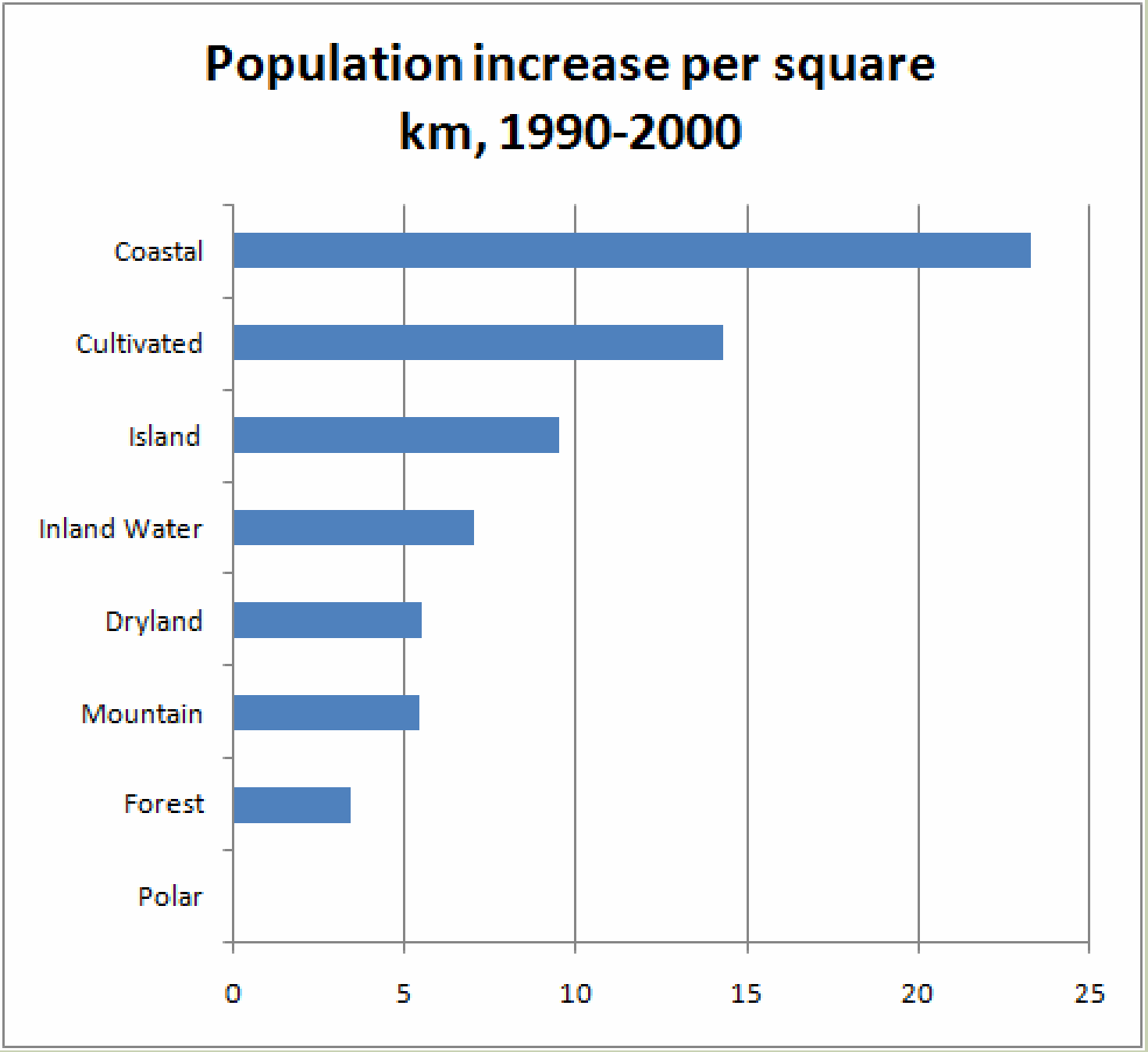
Source: UNEP 1992

Table 5.2. Population Growth within MA Systems, 1990–2000

System	Change in Population (million)	Net Change in Population (percent)	Change in Population per Square Kilometer
Cultivated	505.7	14.1	14.3
Dryland	329.6	18.5	5.5
Inland Water	203.5	17.0	7.0
Mountain	171.0	16.3	5.4
Forest	142.1	13.5	3.4
Coastal	140.3	15.9	23.3
Island	67.0	12.3	9.5
Polar	–117.9	–6.5	0.0

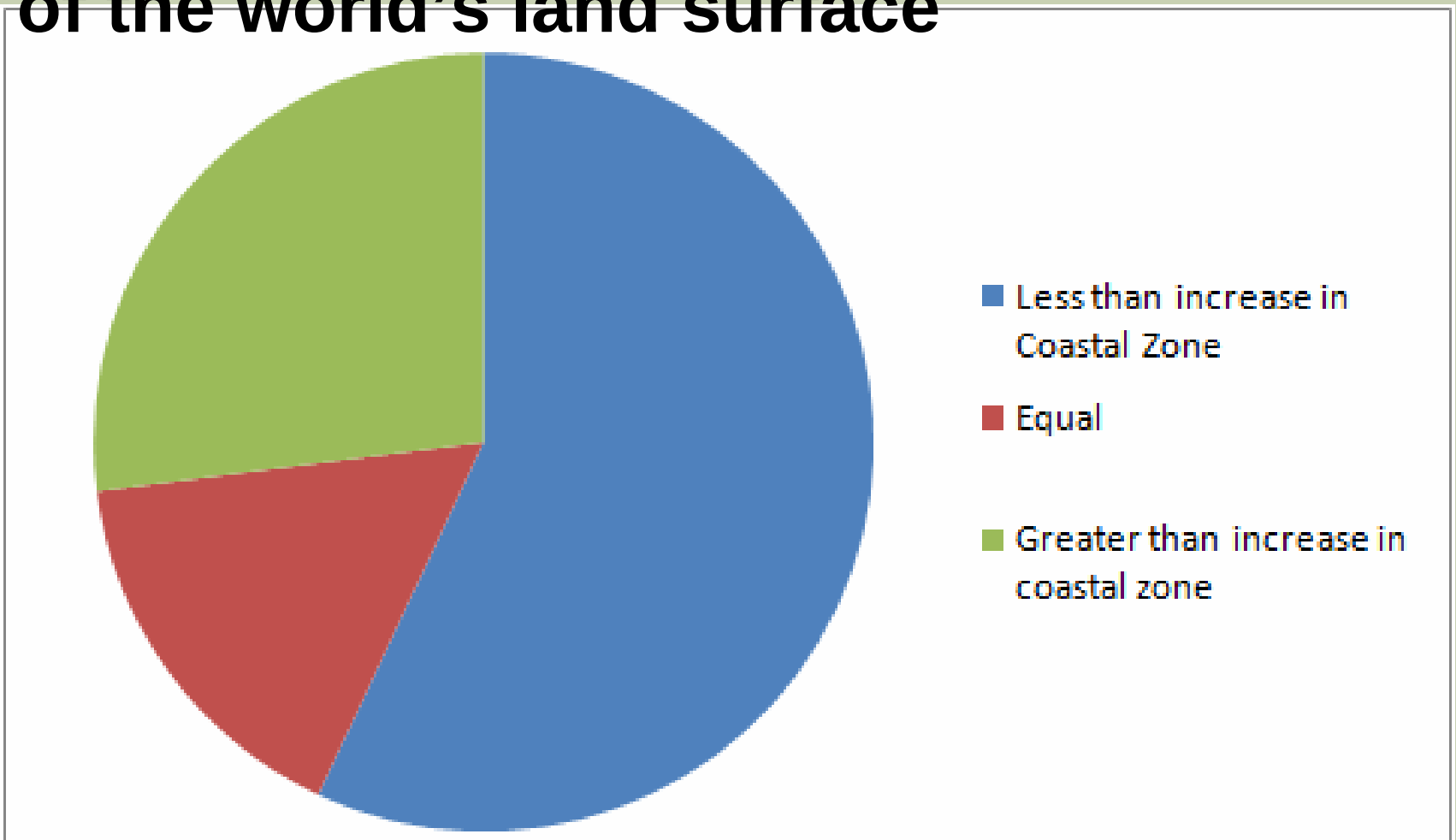
Drylands are a special case: very dangerous combination of

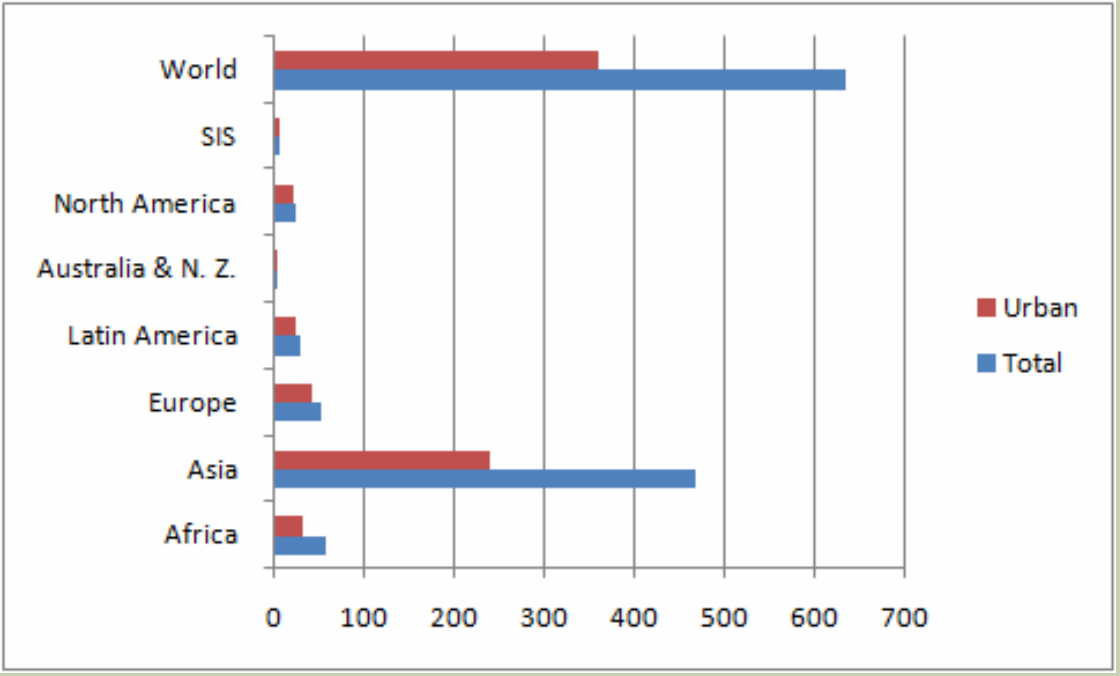
- Poor baseline conditions
-Socioeconomic stresses increasing (esp. population growth)
-Climatic stresses increasing (droughts likely to increase)
- Weak institutional capacity



Coastal areas also under extreme pressure; some are very vulnerable

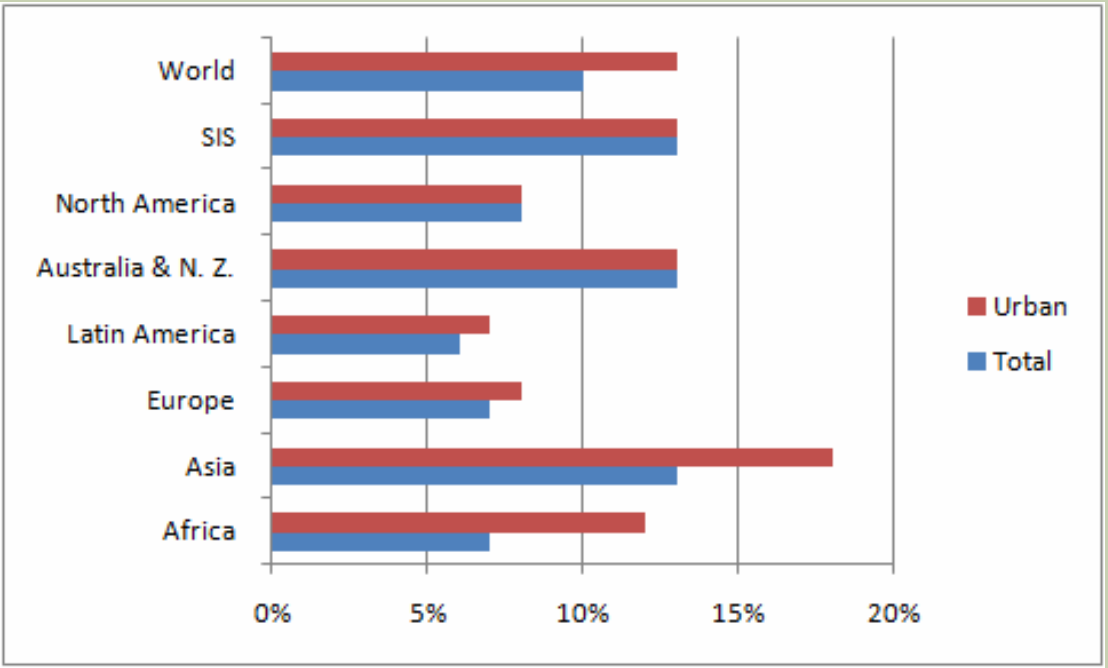
The 1990s *increase* in population density in the coastal zone is greater than current *total* density worldwide, for most of the world's land surface

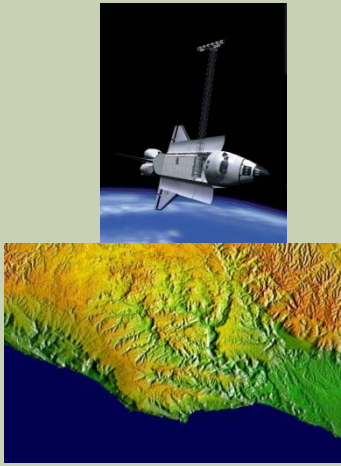




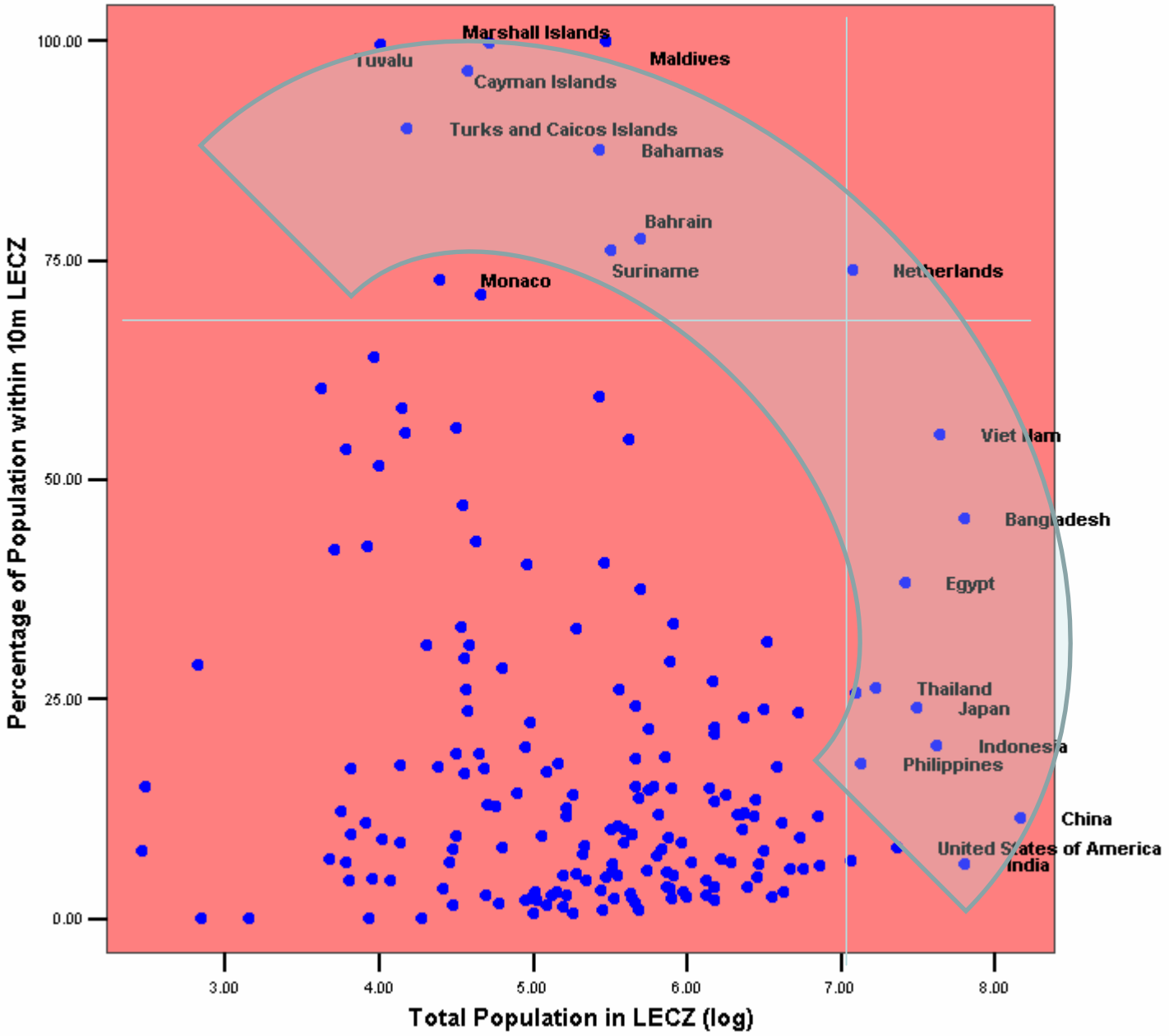
To help characterize sea-level rise risk, we identified 10-meter "Low-Elevation Coastal Zones" (LECZs) and counted population within them, by country

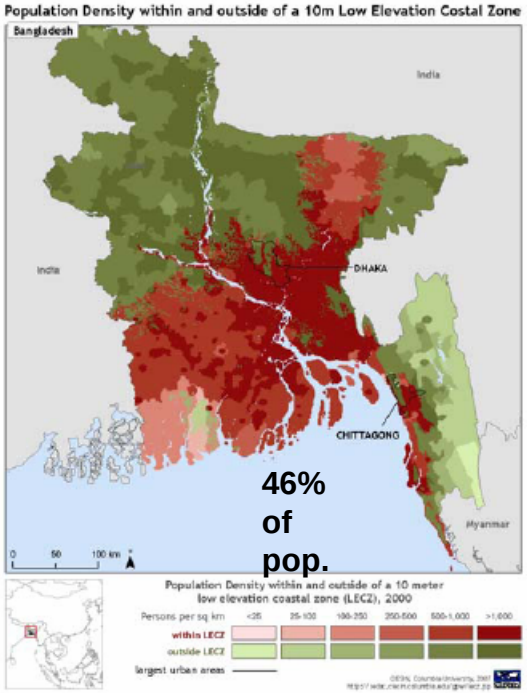
Total Population in 10-m LECZ

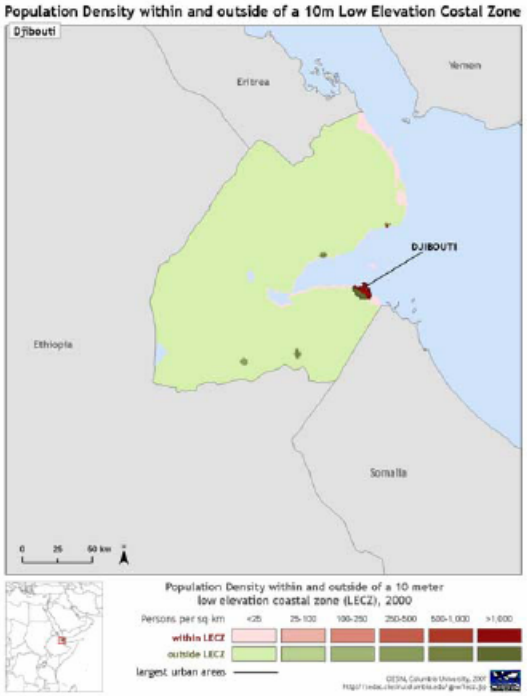




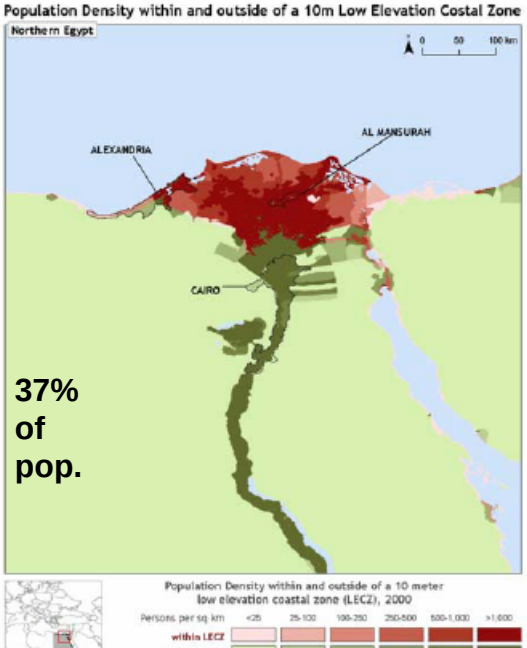
Percentage of Population in 10-m LECZ

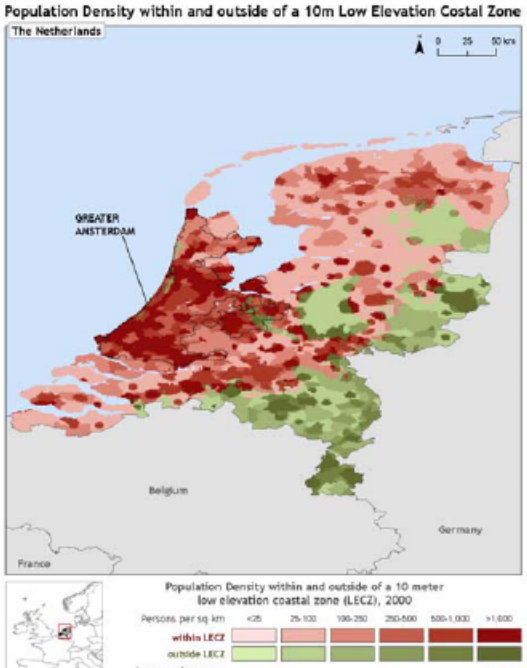

Marshall Islands
Maldives
Tuvalu
Cayman Islands
Turks and Caicos Islands
Bahamas
Bahrain
Suriname
Monaco
Netherlands
Viet Nam
Bangladesh
Egypt
Thailand
Japan
Indonesia
Philippines
China
United States of America
India
100.00
75.00
50.00
25.00
0.00
Percentage of Population within 10m LECZ
3.00
4.00
5.00
6.00
7.00
8.00
Total Population in LECZ (log)





Almost all of Djibouti's population lives in the capital city, which is largely within the 10-meter LECZ. As a result, 41% of the country's population is within the LECZ.





There are dense population centers throughout the Netherlands, but because so much of the country is at low elevations, 74% of the population lies within the 10-meter LECZ -- the 5th-highest value in the world.

3) The patterns are uneven, and surprising catastrophes are likely

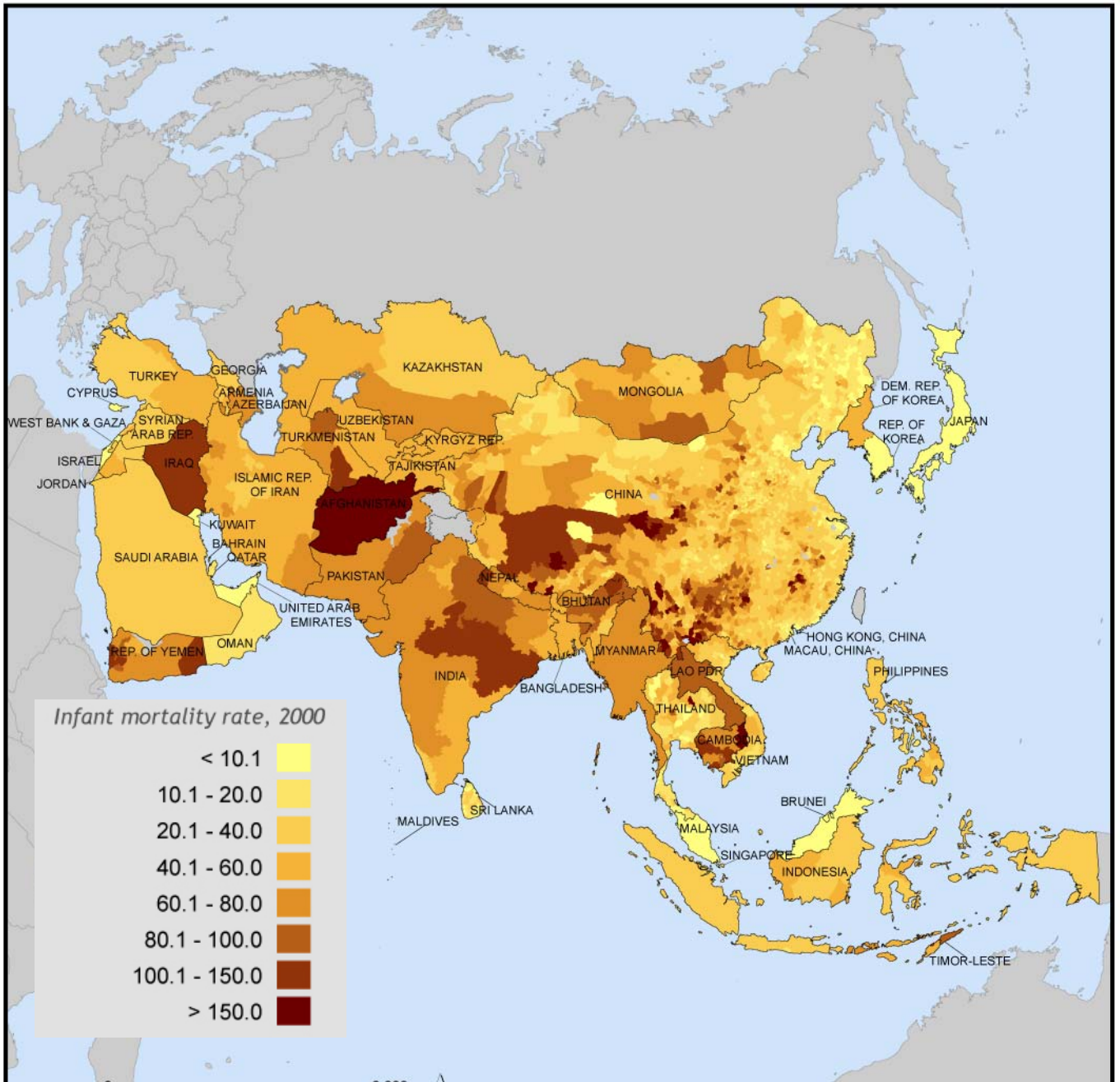
Vulnerability is a function of physical exposure to hazards and underlying socioeconomic patterns of resilience.

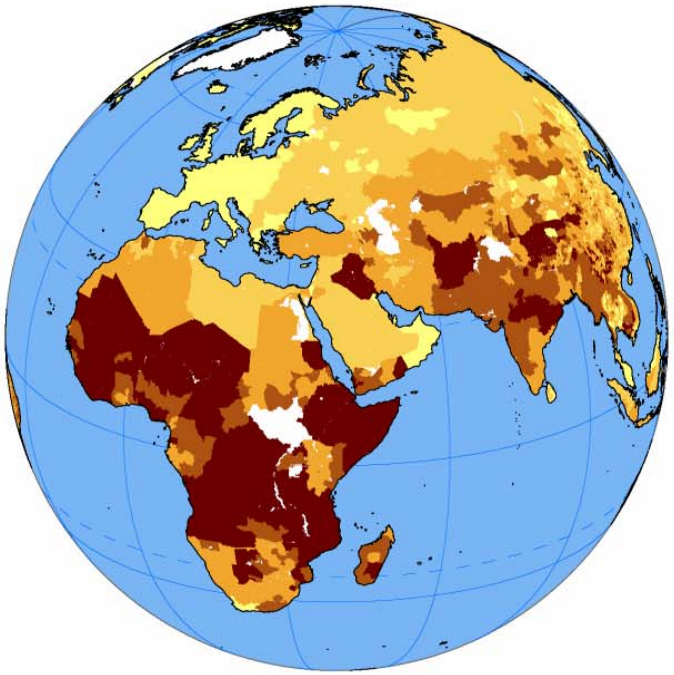
Both exposure and resilience are distributed highly unevenly, in complex ways

We can identify some regions as more dangerous than others, but we cannot reliably predict end-of-chain consequences

There are good reasons to be worried about high-impact catastrophes

Figure 3.4. Asia, Infant Mortality

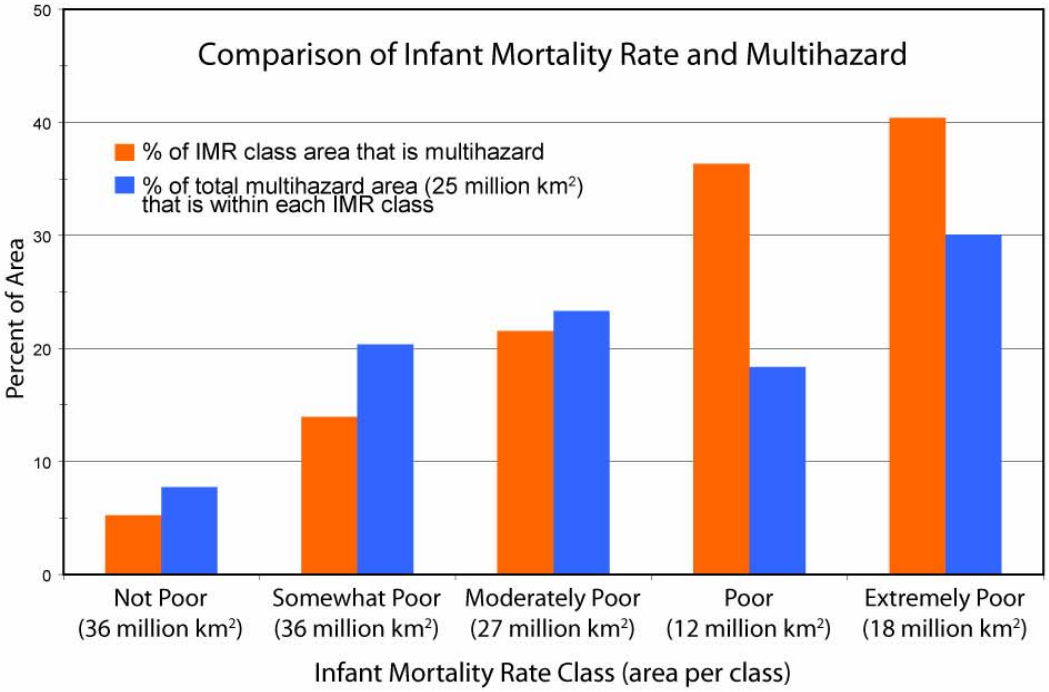


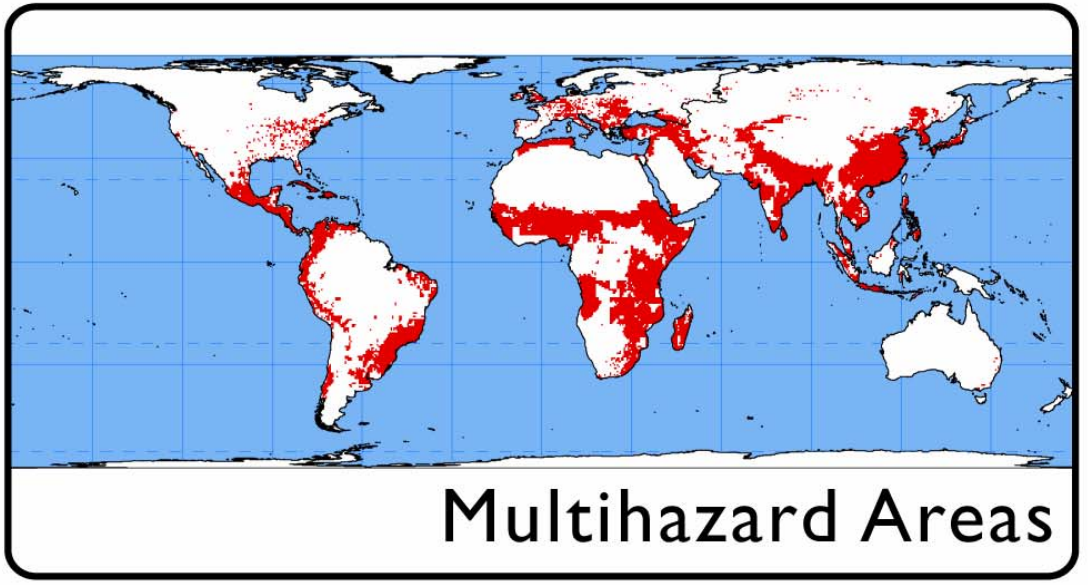


Infant Mortality Rates

(per 1,000)

Not Poor	1.9 - 15
Somewhat Poor	15.1 - 32
Moderately Poor	32.1 - 65
Poor	65.1 - 100
Extremely Poor	> 100

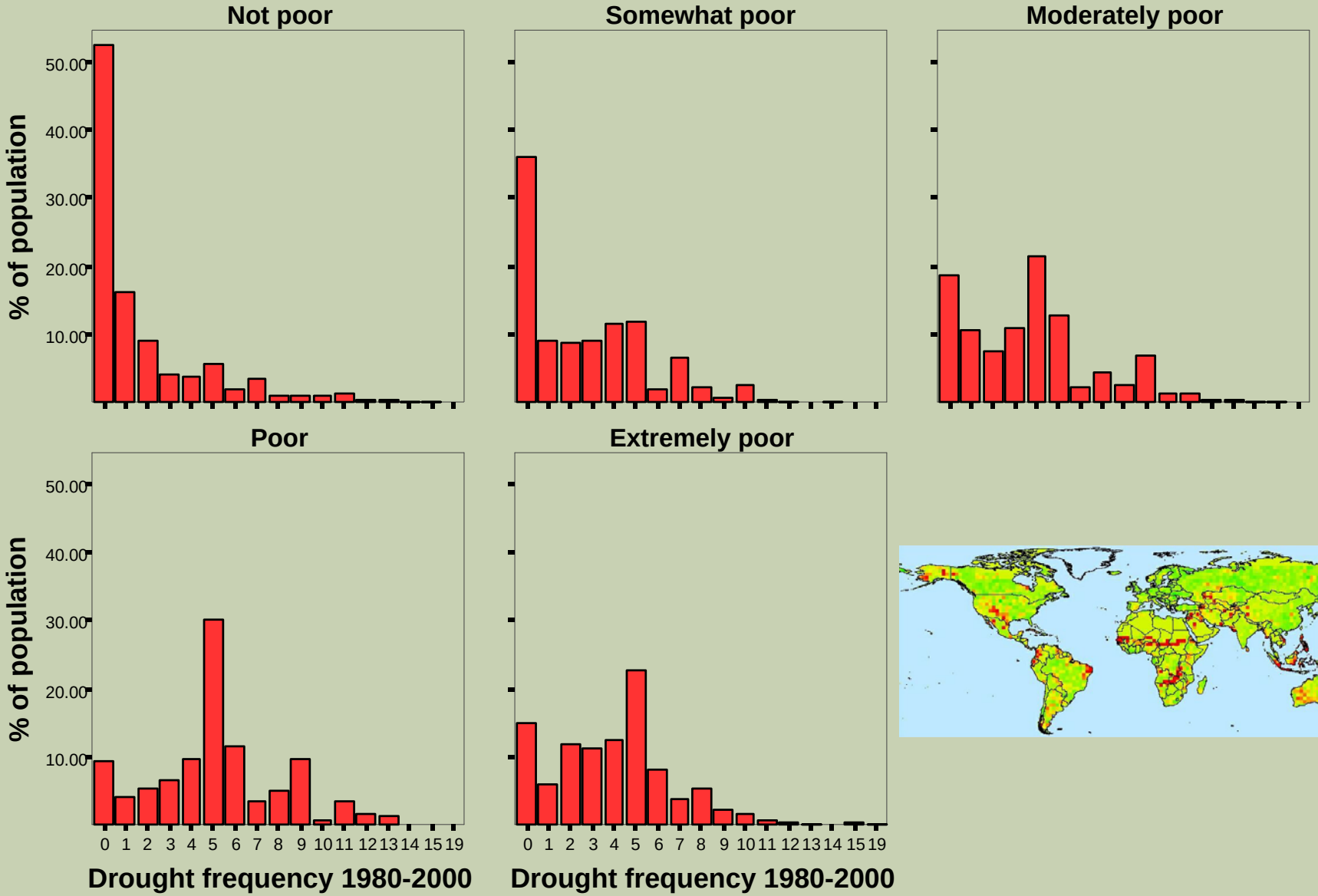




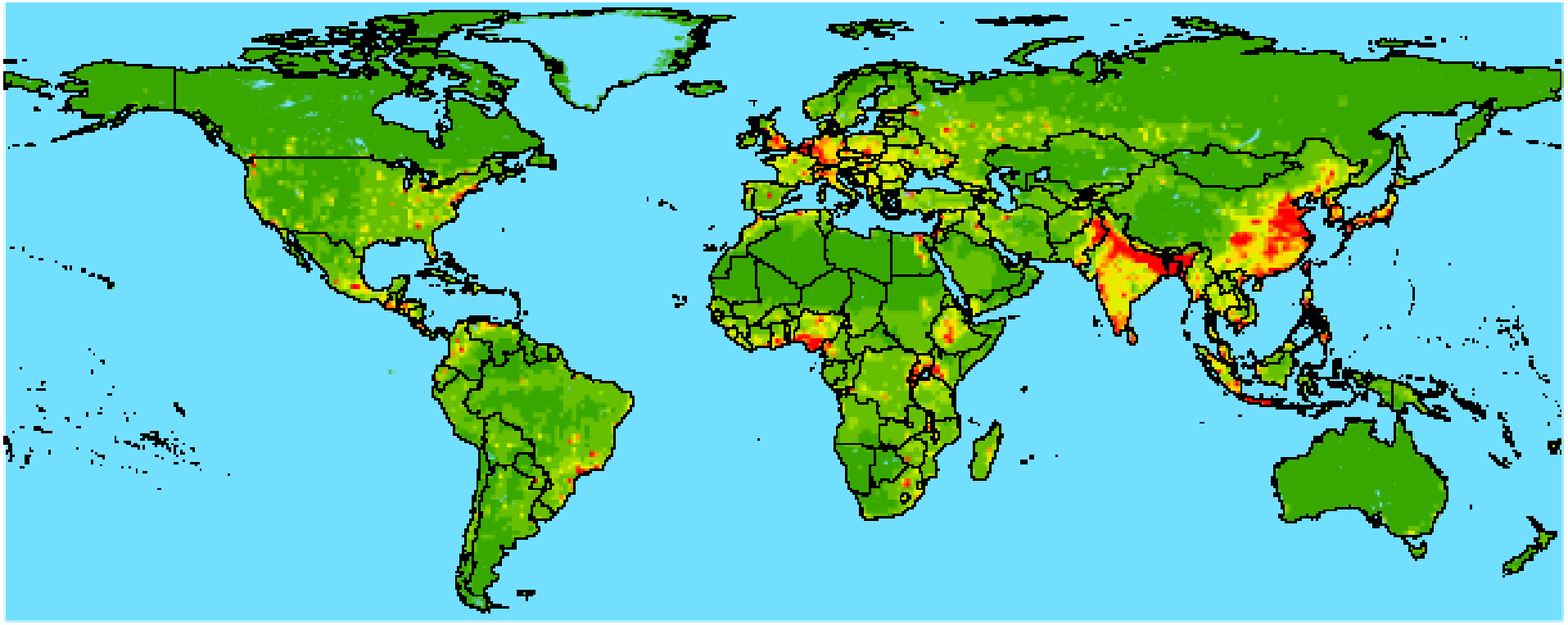
Multihazard Areas

Drought

(3 consecutive overlapping 3-month seasons with rainfall at least 50% below normal)

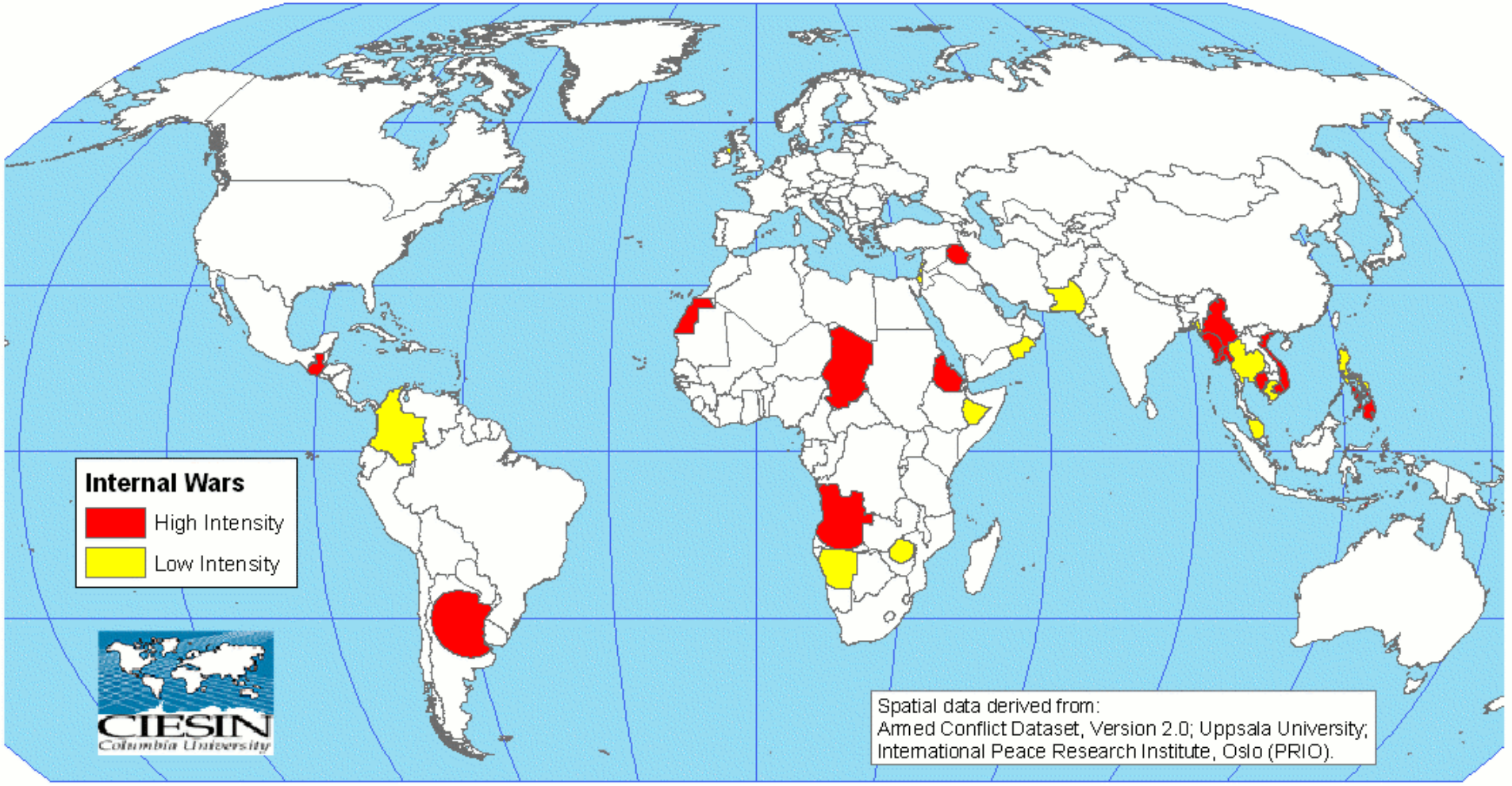


Emerging Infectious Disease Outbreak Risk



Determined through analysis of historical spatial pattern of all known EIDs, examining effect of human population, wildlife population, and climate

1975


Internal Wars
High Intensity
Low Intensity
CIESIN
Columbia University
Spatial data derived from:
Armed Conflict Dataset, Version 2.0; Uppsala University;
International Peace Research Institute, Oslo (PRIO).

Conditional Probability of High-Intensity Outbreak, by Rainfall Deviation Decile, given ongoing Low or Medium Intensity Conflict

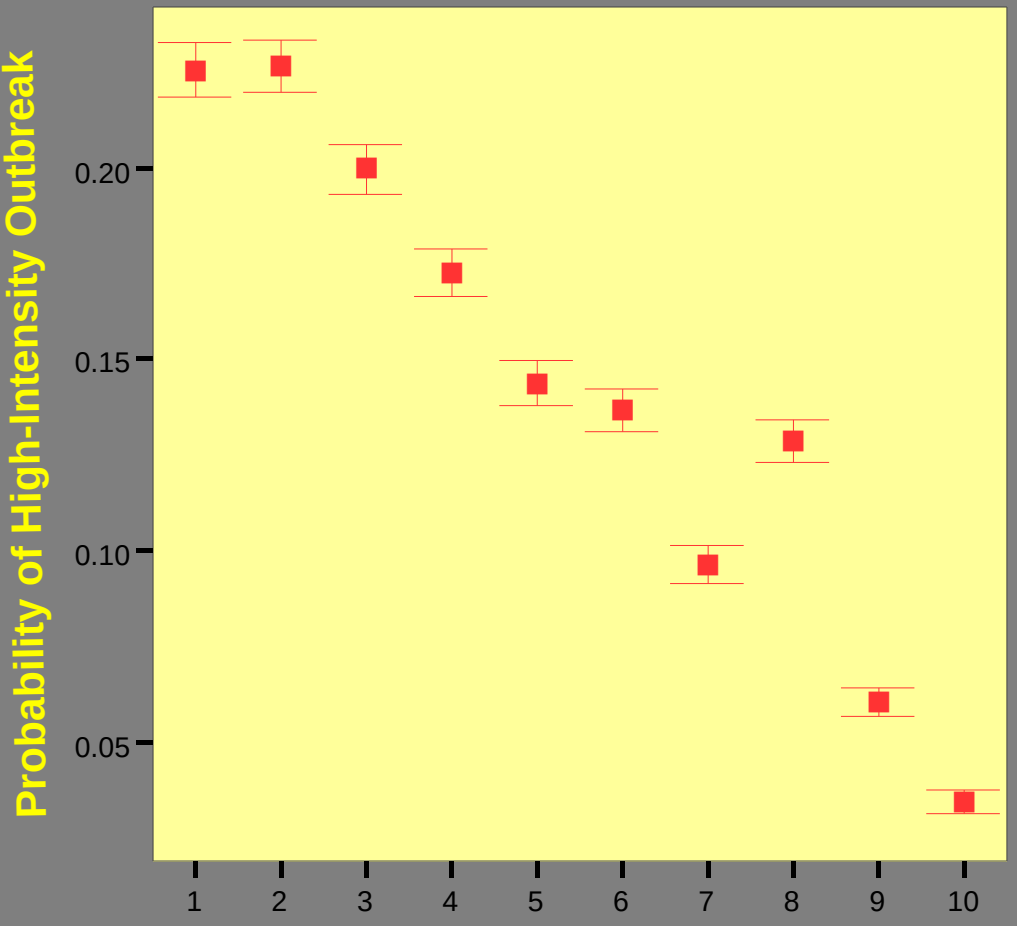
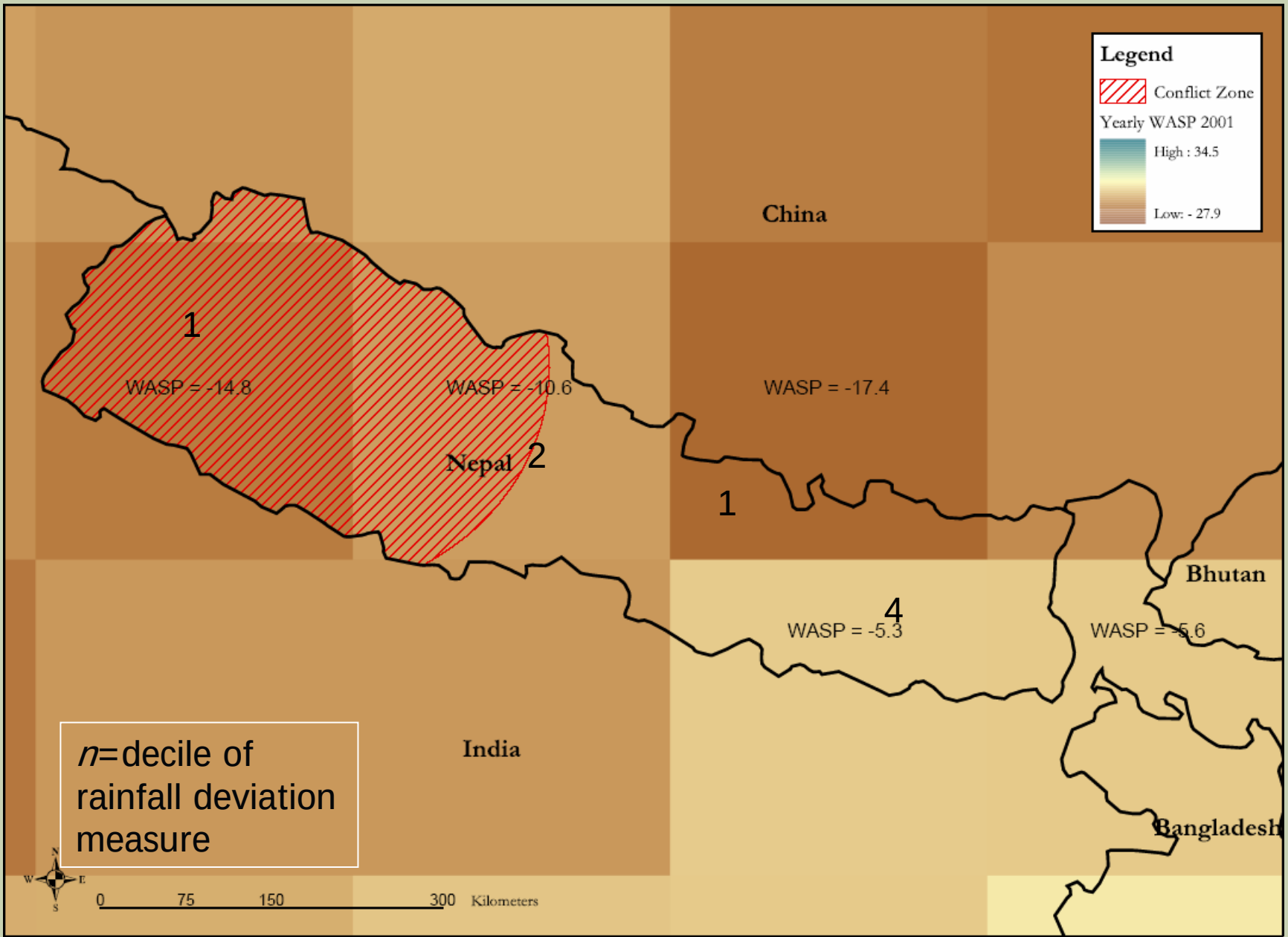
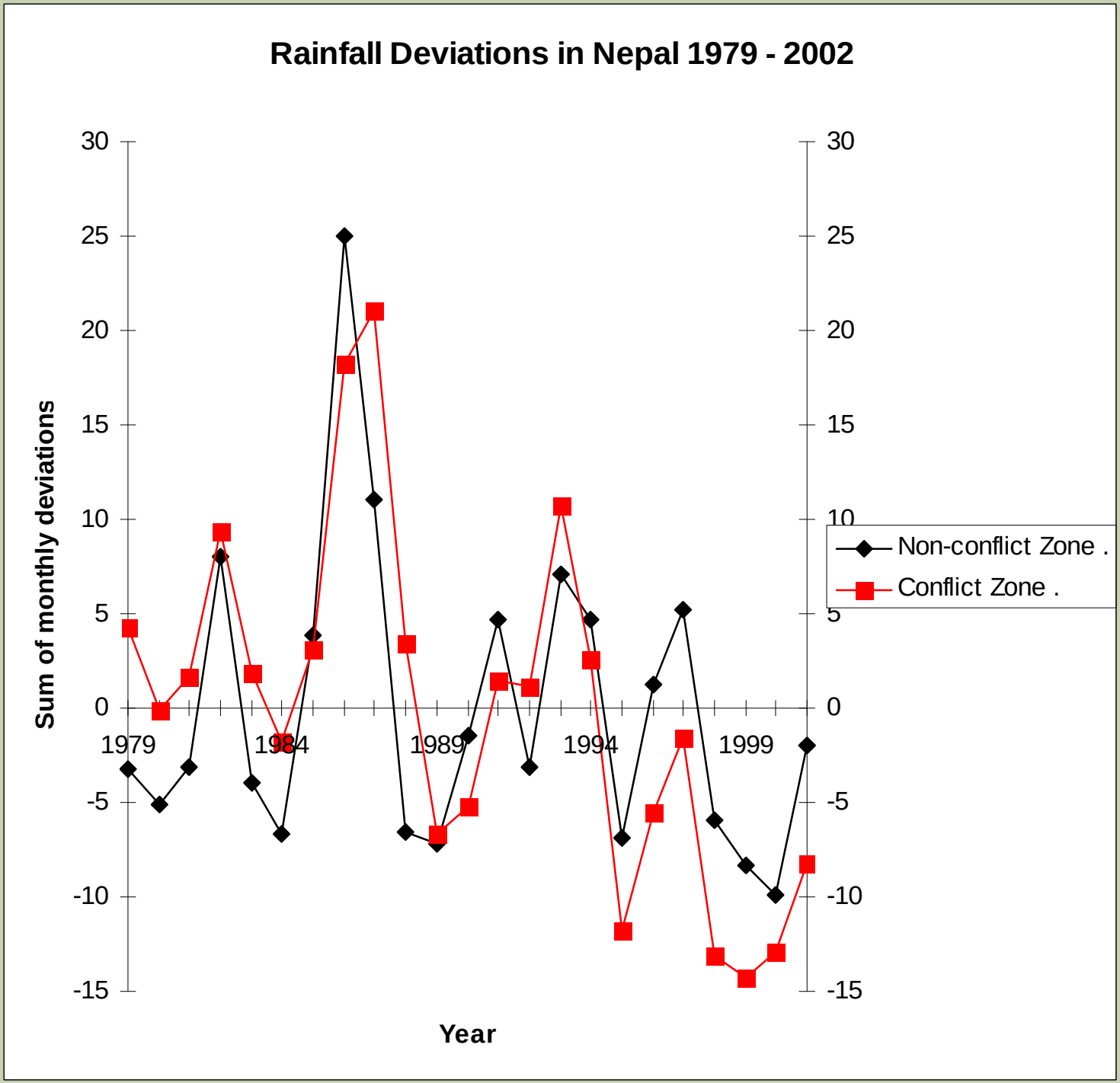


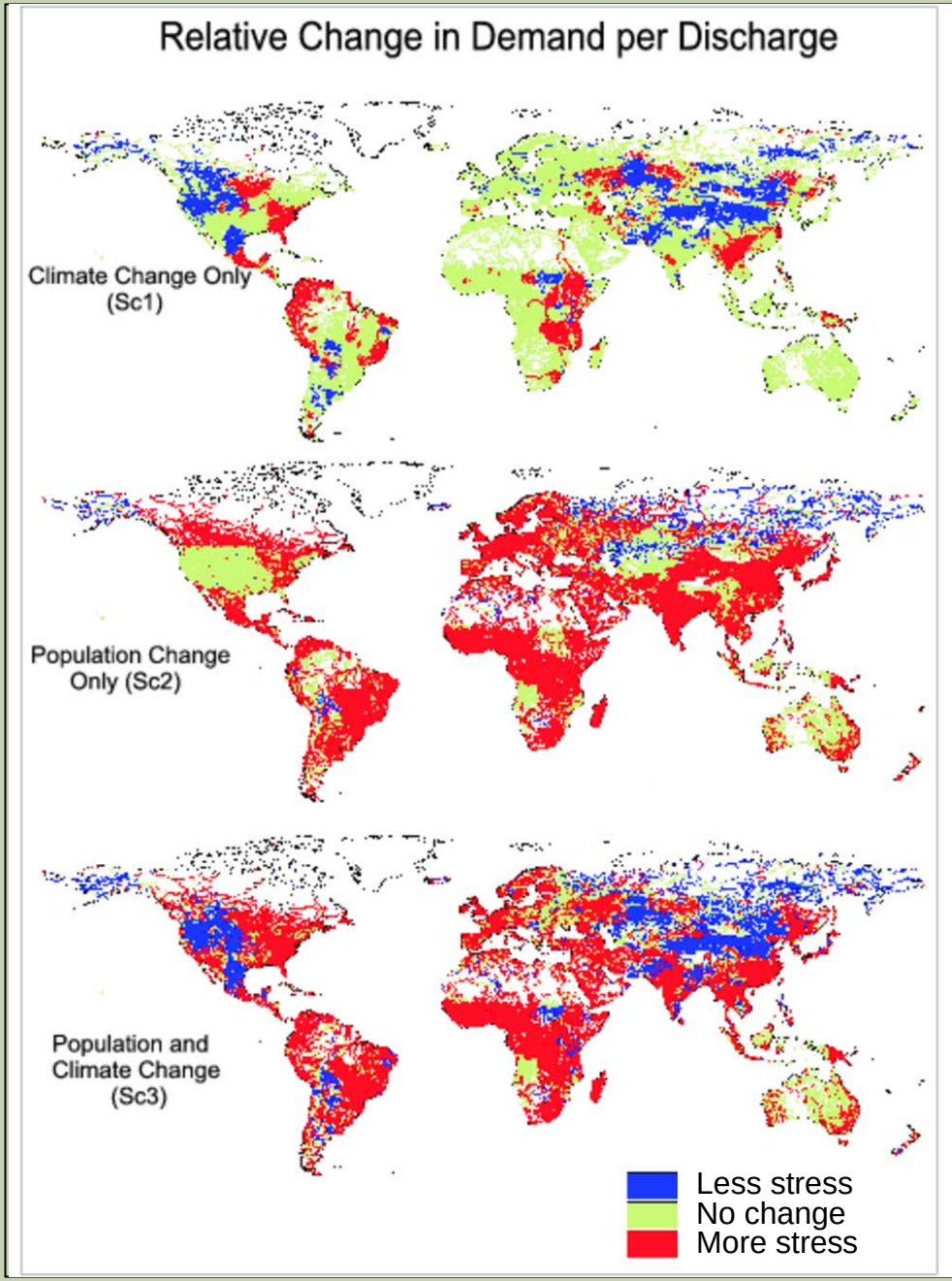
Illustration: Nepal 2002 Outbreak




Rainfall Deviations in Nepal 1979 - 2002
Sum of monthly deviations
Year
30
25
20
15
10
5
0
-5
-10
-15
1979
1984
1989
1994
1999
Non-conflict Zone .
Conflict Zone .

Water Stress Changes to 2025

- 80% of future stress from **population** & **development**, not **climate change**!
- Future distortions of the water cycle are inevitable



Source: Vörösmarty et al. 2000

UNH

4) There are no easy responses – it will take sustained, focused efforts

What would be most helpful:

Comprehensive assessment of vulnerability to natural hazards in context of both global change and socioeconomic change

- **Baseline vulnerability to natural hazards**
- **Plausible projections of physical and social stresses**
- **Identification of simple, direct threats (floods, droughts, disease, etc)**
- **Elaboration of complex scenarios of interest**
- **Articulation of strategies to increase resilience and preparedness**

Military sector cannot do this in a vacuum

What's at stake is more than simple ability to cope with disasters; government legitimacy also vulnerable