Climate change and health
(in the era of COVID-19)

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Lecture's Objectives

First, the lecture's conclusion! Given the urgency of the climate change crisis, preventive medicine and public health professionals can play a vital role to forecast, evaluate, and prevent adverse health consequences of global warming.

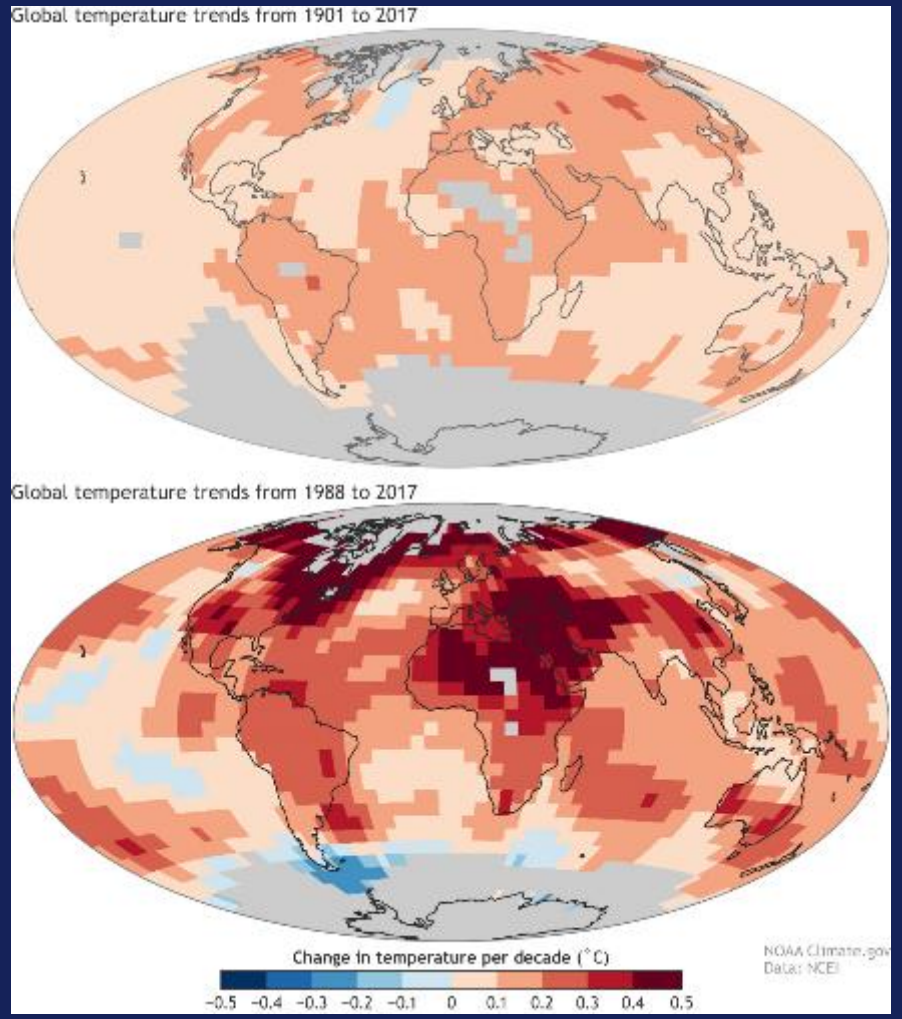
- Learn key facts about global climate change and human activity
- Understand the ways that global climate change is threatening human health
- Recognize methodological challenges in doing research in climate change and health
- Apply knowledge towards mitigation strategies to reduce human health harms due to climate change

Global threats to the environment of human origin

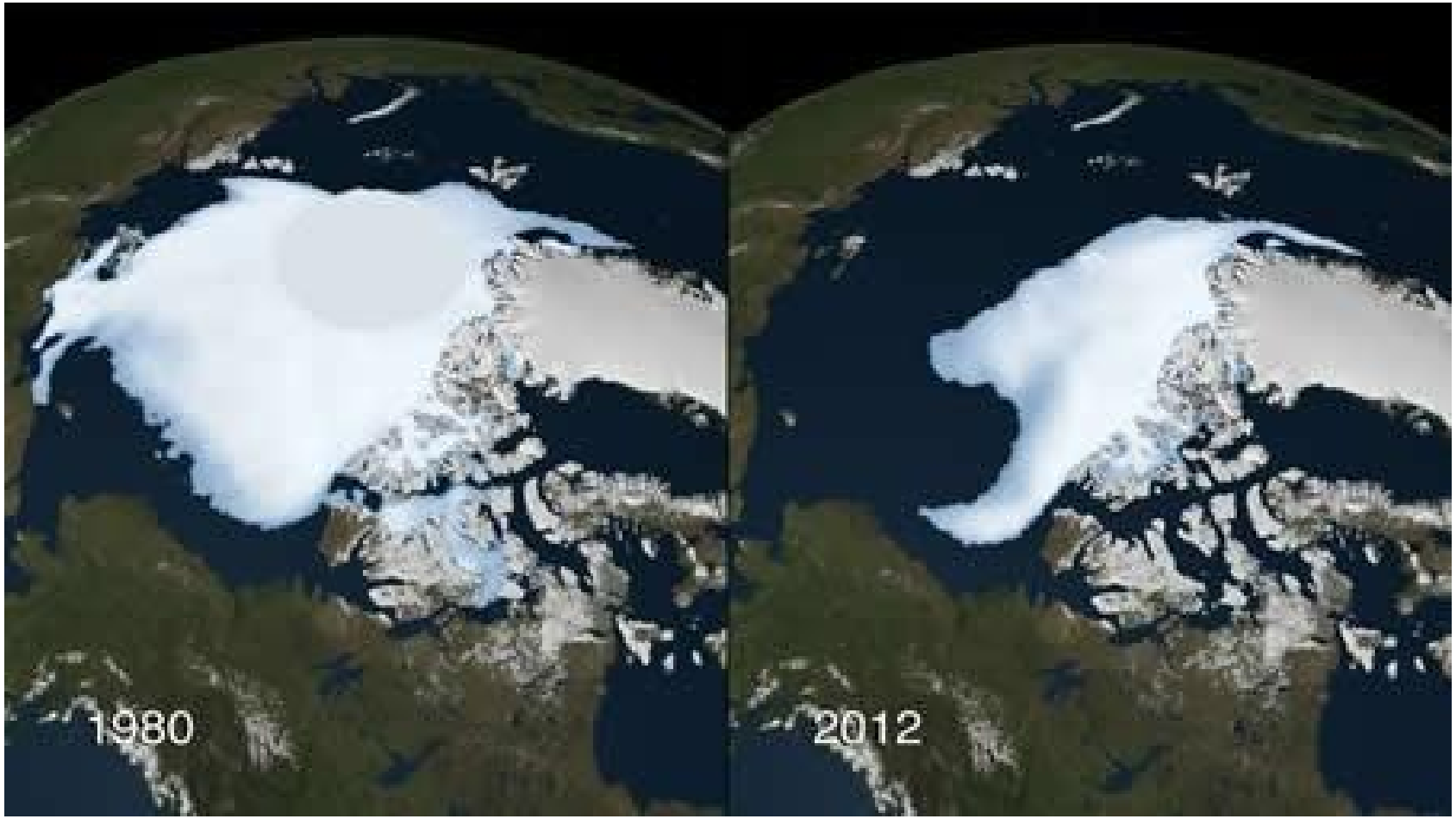
- **Global climate change** (known as global warming, until renamed by a political lobbyist)
- Direct human effects
  - Hotter and drier summers (heat related deaths)
  - Warmer and wetter winters (loss of polar/glacial ice)
  - Increased extreme weather (adverse events)*
  - Property (especially coastal) and crop loss
  - Loss of fish (ocean biodiversity) starting with loss of reef ecosystems

*Net Hurricane Power Dissipation Highly Correlated w/ Tropical Sea Surface Temp. *Nature* 2015
*Increased Sea Surface Temperatures and Greater Hurricane Intensity. *Science* 2005
Ebi KL, et al. Extreme Weather and Climate Change: Population Health and Health System Implications. *Annu Rev Public Health* 2021;42:293-315.

Annual Mean Surface Temperature Anomaly (°C)



- 7 warmest years in recorded history in past 7: 2014–2020
- 2020 globally averaged temp. was 1.02° C. (1.84°F.) hotter than the baseline mean of 1951-1980
- Results: loss of sea ice and ice sheet mass, sea level rise, longer intense heat waves, plant and animal habitats changes

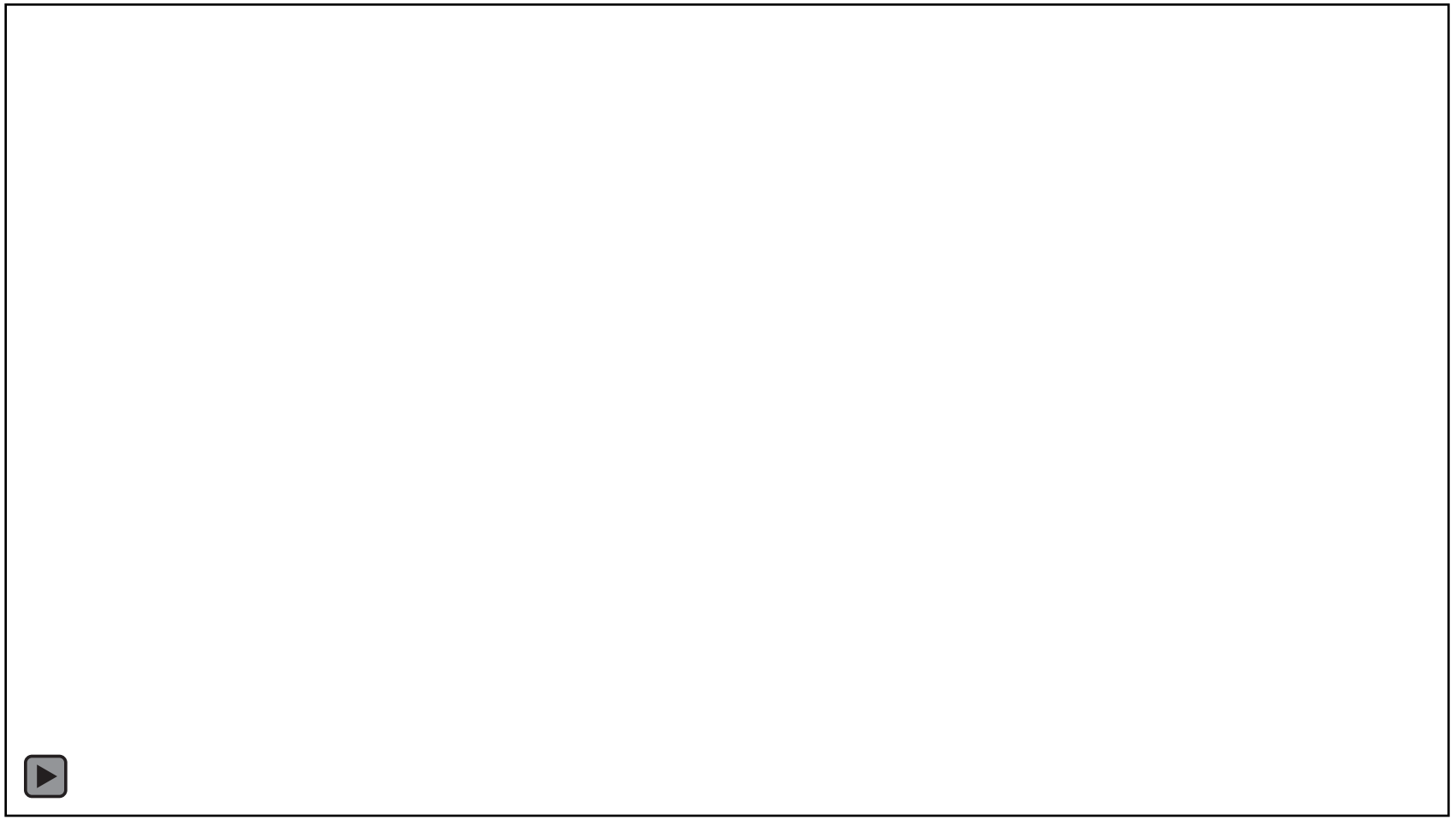


Size of summer Arctic polar ice cap shrinking 9% per decade,

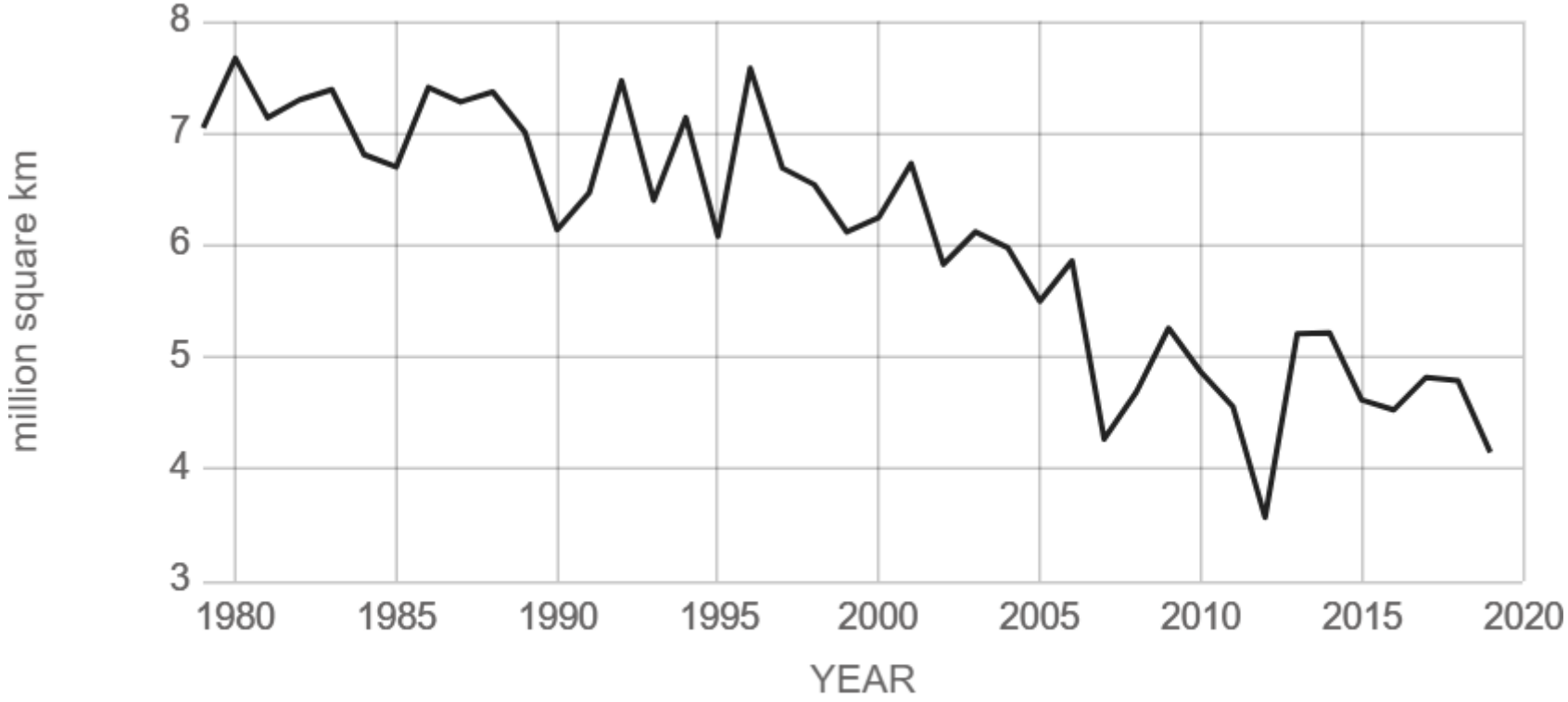
as much is the last 10 years as in the previous 10,000 years.

- **https://sites.google.com/a/seoulforeign.org/erica-kim-s-science-journal/Home/global-environmental-issue**
- Witze A. Arctic sea ice hits second-lowest level on record. *Nature* 22 September 2020 https://www.nature.com/articles/d41586-020-02705-7

Video: Antarctic ice loss: 2002-2016



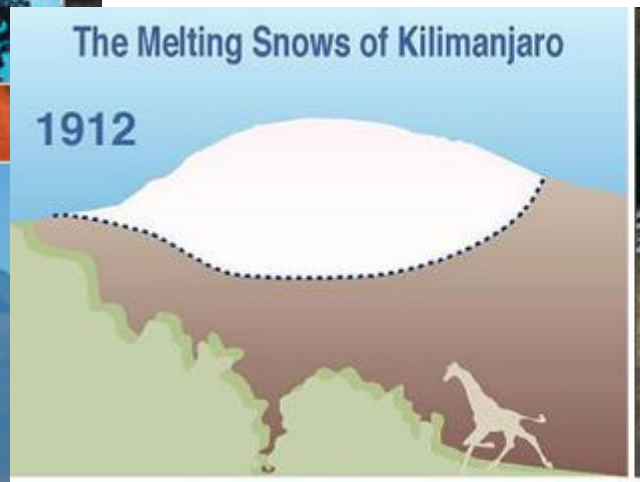
Global Sea Ice Halved in past 40 years

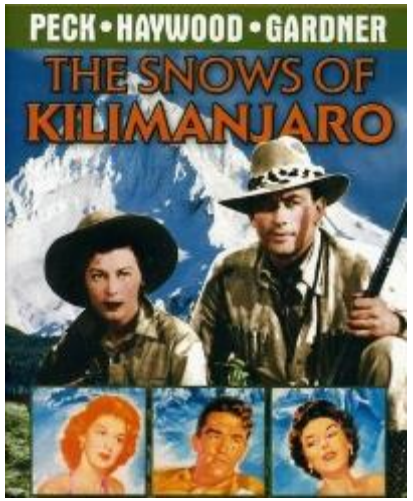


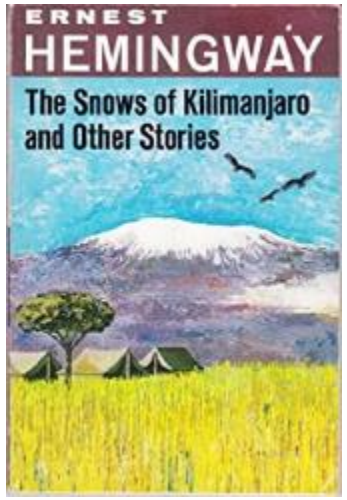
Source: climate.nasa.gov

Mount Kilmanjaro: Africa's highest peak

- Deforestation and global warming
- Malaria now in the foothills







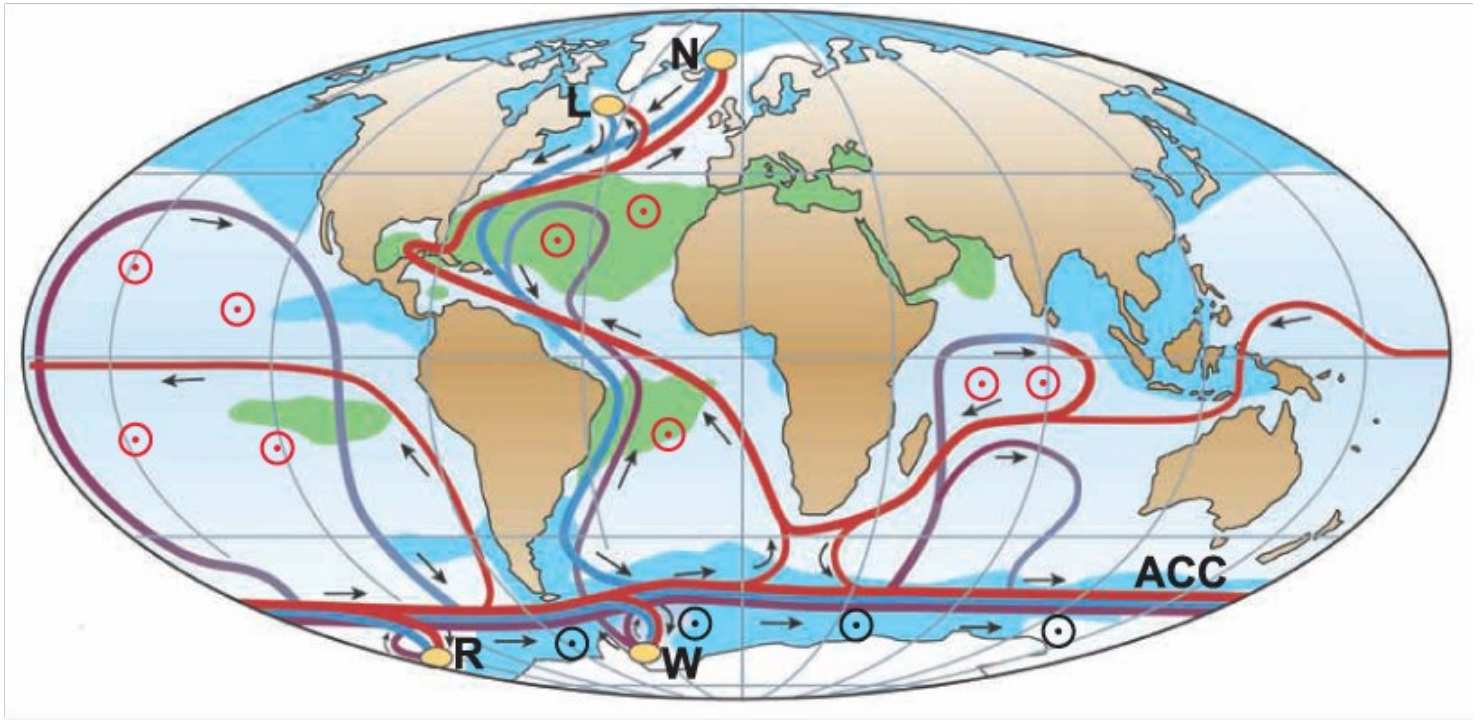
Evidence for global climate change

- Irrefutable and overwhelming
  - Analogous to HIV & AIDS, COVID-19 & SARS-CoV-2, smoking & lung cancer, HPV & cervical cancer, asbestosis & mesothelioma,
- Scientists who disagree are typically on the payrolls of interested parties, e.g., fossil fuel industry and their media advocates
  - Major climate change denial “experts” brought to debate climate change scientists on TV are typically paid lobbyists without any scientific background

Thermohaline Circulation

The ocean is a vast heat store and North-South, East-West circulator

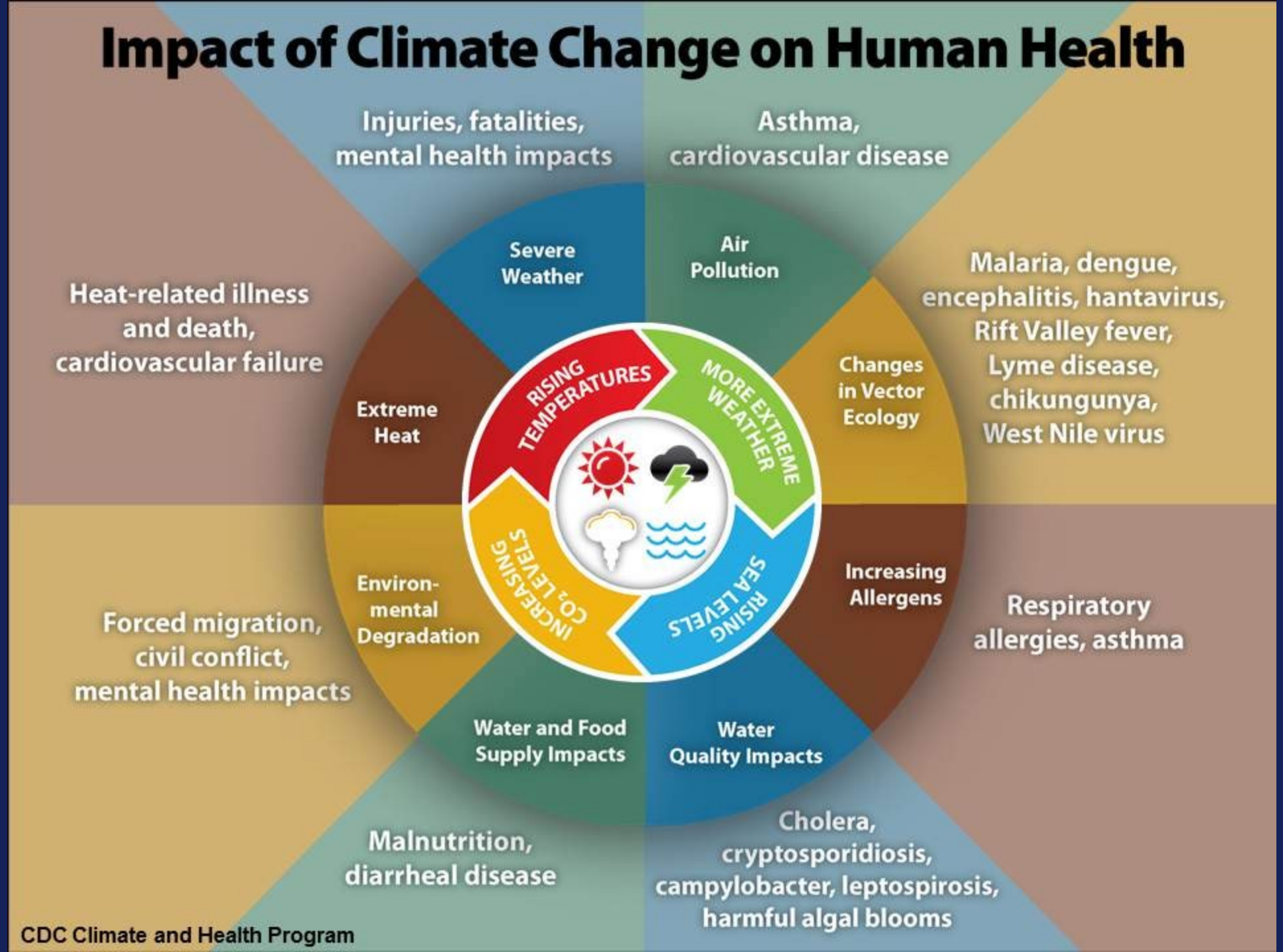
Atlantic current: Meridional overturning circulation (MOC)



http://www.eoearth.org/view/article/150290/

Health Issues

1. **Direct effects of heat**
2. Climatological displacement (climate refugees) and extreme weather events
3. Vector-borne diseases
4. Population pressures → shrinking land/water assets
5. Evolving drought and flood cycles --> famine risk


Impact of Climate Change on Human Health
Injuries, fatalities, mental health impacts
Asthma, cardiovascular disease
Severe Weather
Air Pollution
Heat-related illness and death, cardiovascular failure
Malaria, dengue, encephalitis, hantavirus, Rift Valley fever, Lyme disease, chikungunya, West Nile virus
Extreme Heat
Changes in Vector Ecology
RISING TEMPERATURES
MORE EXTREME WEATHER
INCREASING CO2 LEVELS
RISING SEA LEVELS
Environ-mental Degradation
Increasing Allergens
Forced migration, civil conflict, mental health impacts
Respiratory allergies, asthma
Water and Food Supply Impacts
Water Quality Impacts
Malnutrition, diarrheal disease
Cholera, cryptosporidiosis, campylobacter, leptospirosis, harmful algal blooms
CDC Climate and Health Program

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44 Countries and Regions Especially Vulnerable to Climatological Events

Alliance of Small Island States

aosis.org

Areas subjected to inundation w/ 1m rise in sea level

Source: Corell RW, 2004: Impacts of a warming Arctic. *Arctic Climate Impact Assessment* Cambridge University Press

Global warming may affect storm formation and intensity (e.g., hurricanes, cyclones, tornados). How?

- As temperatures rise, more and more water vapor evaporates into the atmosphere → "fuel" for storms
- More heat and water in the atmosphere combined w/warmer ocean surface temperatures increases the wind speeds of tropical storms
- Analogous phenomena with temperature inversions can drive tornados
- Droughts and floods also facilitated

http://earthobservatory.nasa.gov/Features/RisingCost/rising_cost5.php

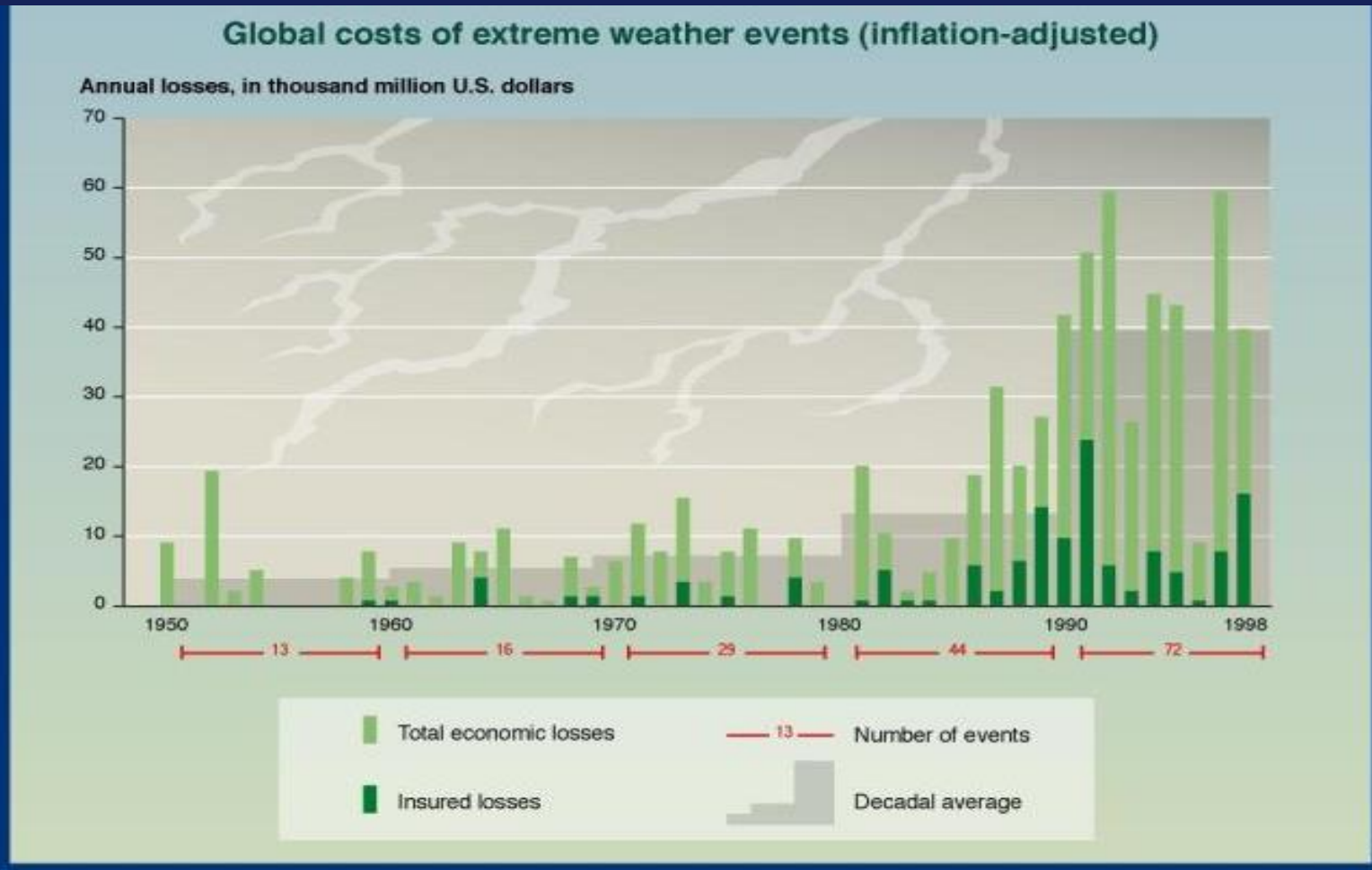
Hurricane Sandy: 29-31 Oct. 2012

- Record rain, wind, and storm surges
  - 23,000 homeless and 8.5 M no power in NJ, NY, and 12 states
- Costs incurred within just one year…
  - $1.4 B in Individual Assistance provided to >182,000 victims
  - $2.4 B in low-interest disaster loans approved by the SBA
  - >$7.9 B in National Flood Insurance Program payments made
  - FEMA approval for $3.2 B for emergency response and rehab

Hurricanes Maria (Sept. 2017) and Dorian (Sept. 2019)

Not accounting for inflation, 15 Atlantic hurricanes have resulted in >US$10 B. in damage each, incl. 3 each from 2004, 2005, & 2017. Costliest were Katrina in 2005 & Harvey in 2017, both w/ uninflated damage totaling to $125 B.

Costs of Extreme Weather Events



SYR - FIGURE 2-7

WMO UNEP

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Health Issues

1. Direct effects of heat
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3. **Vector-borne diseases**
4. Population pressures → shrinking land/water assets
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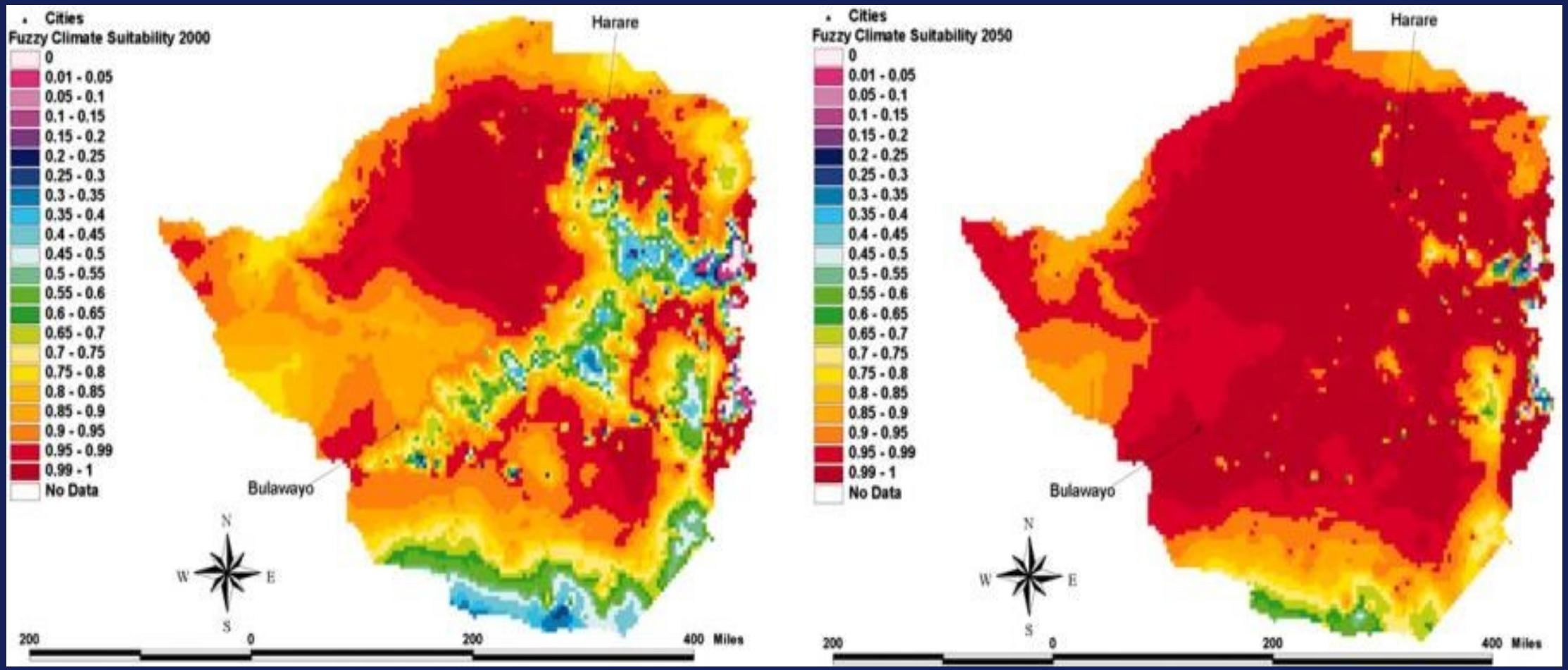
Spread of vector-borne diseases

- Mosquito-related infections
  - Malaria
  - Arboviruses
    - Dengue Fever, Yellow Fever, Zika virus
- Other vector-related infections
  - Filariasis/Onchocerciasis (Blackflies)
  - Schistosomiasis (Snails)
  - Hantaviruses (Rodents)
  - Trypanosomiasis (In Africa, tsetse fly; In Americas, Reduviid bug)
  - Tick-borne diseases, e.g., Lyme disease
- Water-borne diseases, e.g., cholera

Malaria in the highlands of Zimbabwe



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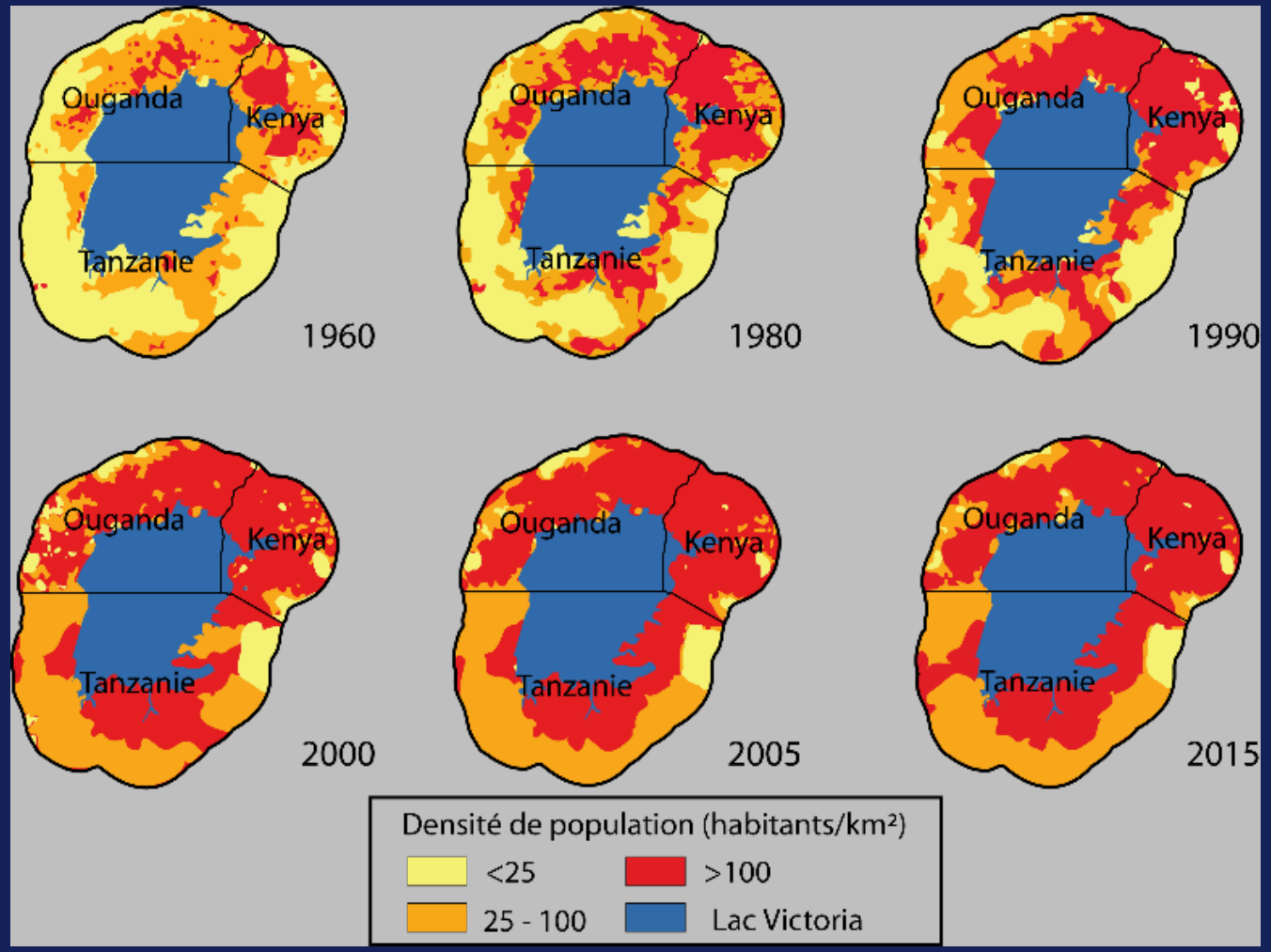
- Education (especially girls/women)
- Unmet need for family planning (and improved maternal/child survival)
- Sustainable economic empowerment

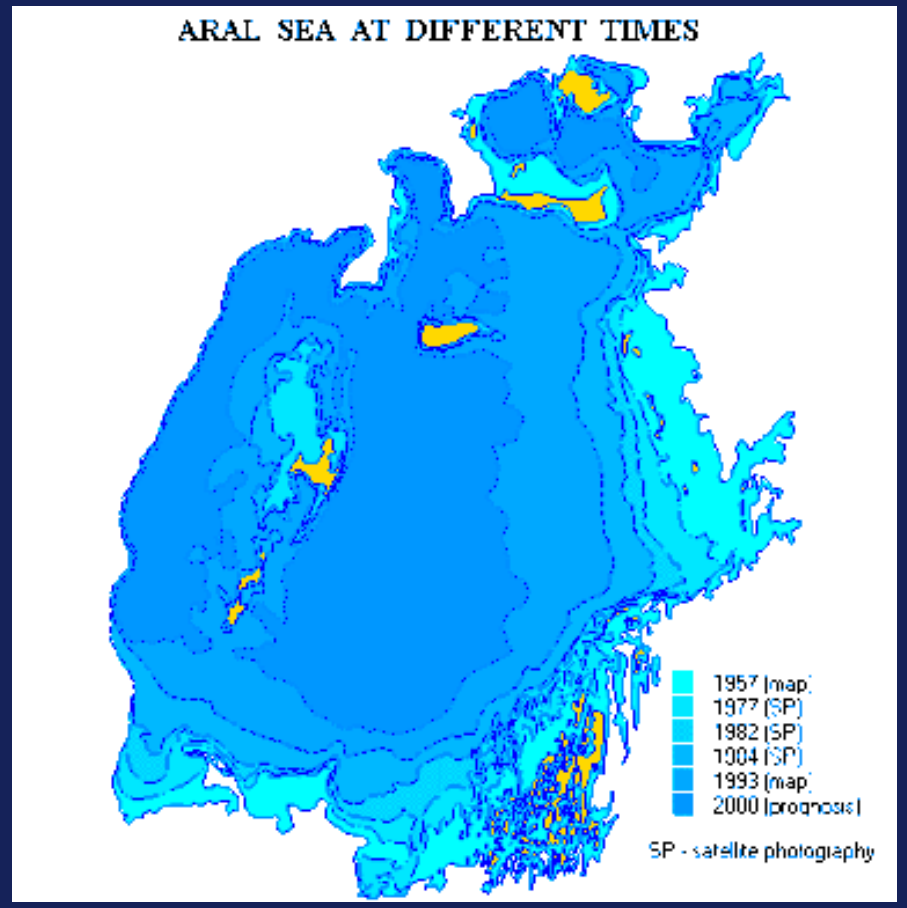
Population Growth Pressure around Lake Victoria



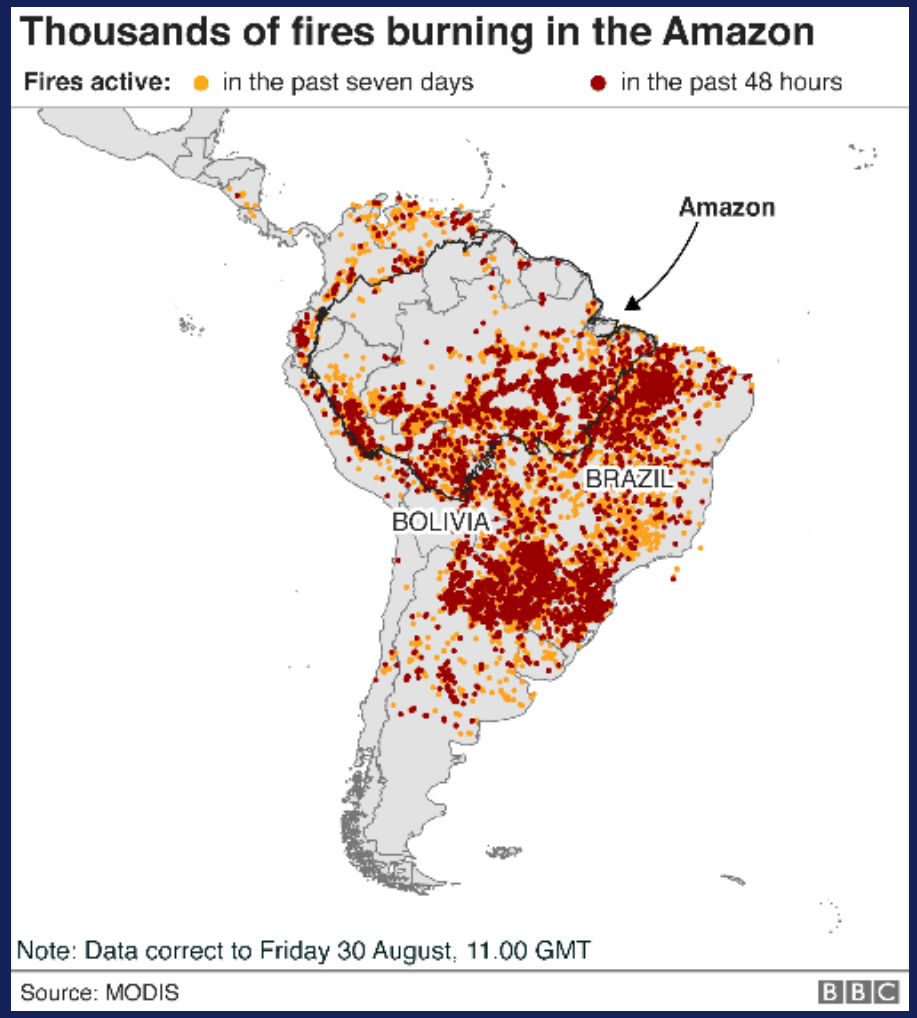
UNEP

Aral Sea is vanishing

as are Lake Chad & California's Mono Lake



Encroaching upon ecosystems that mitigate C02 emissions



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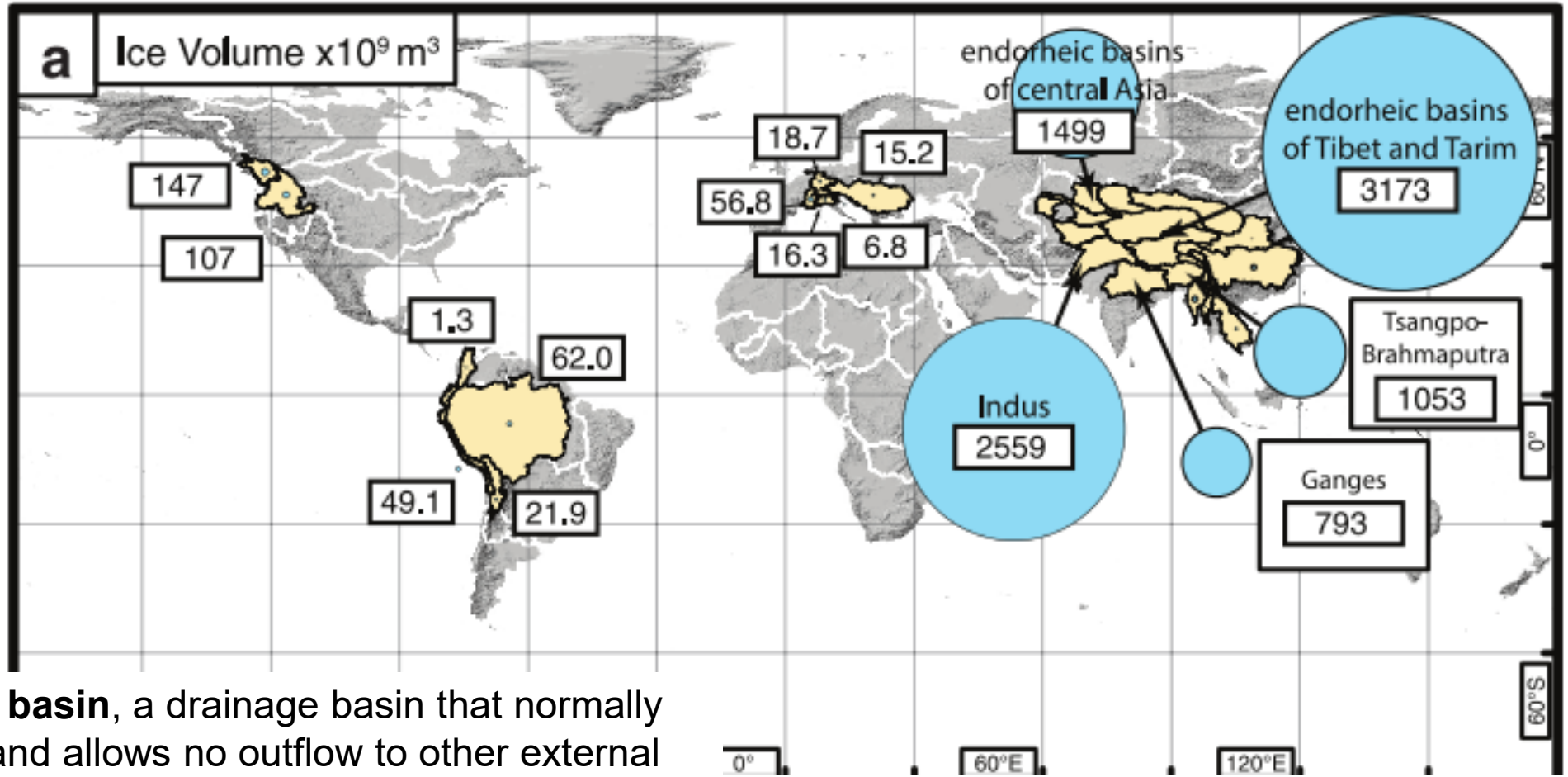
Context: Importance of Frozen Water



An **endorheic basin**, a drainage basin that normally retains water and allows no outflow to other external bodies of water, but drainage converges instead into lakes or swamps that equilibrate through evaporation.

Image Credit: Huss et al., 2017

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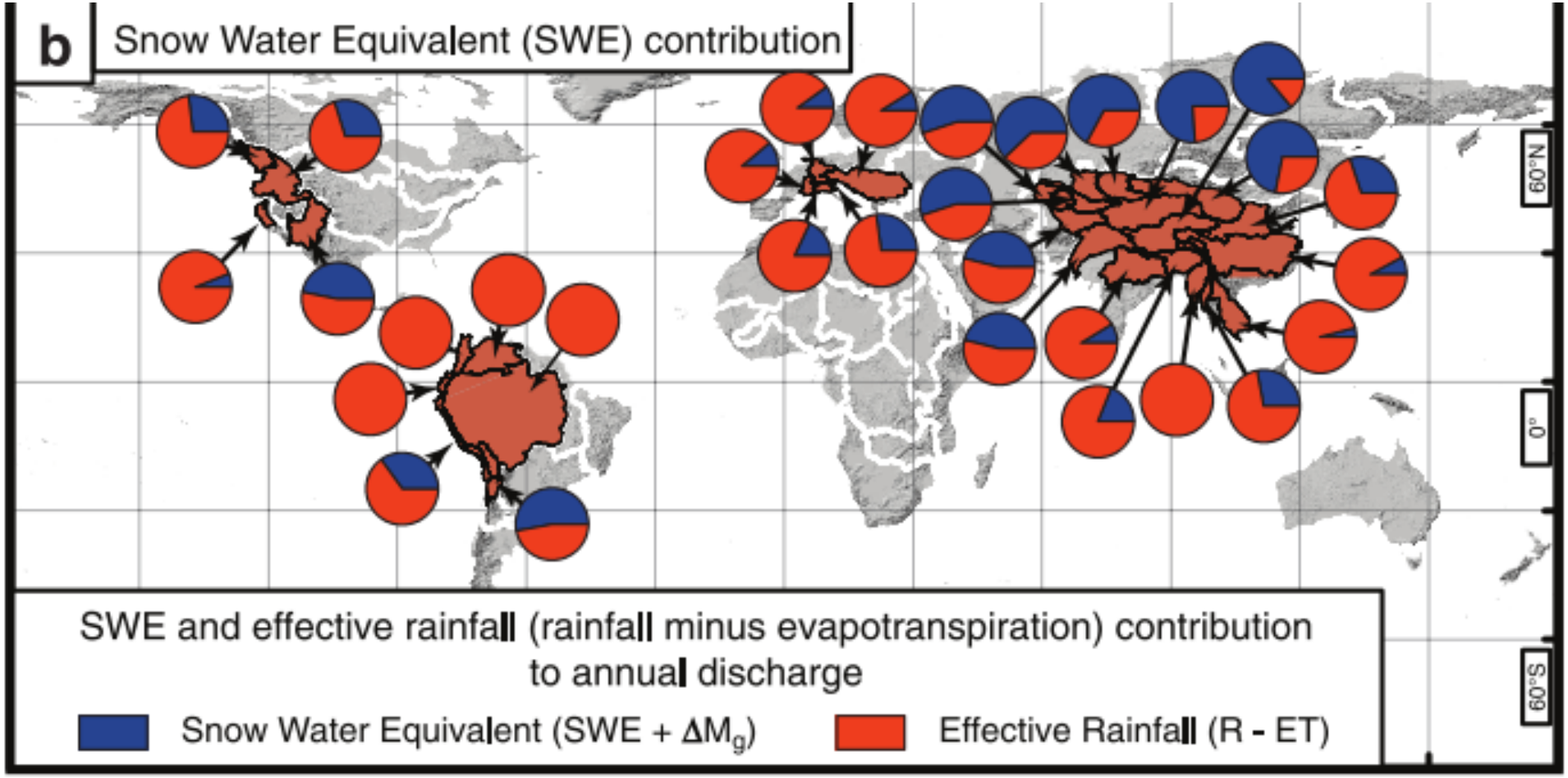


Image Credit: Huss et al., 2017

Context: Glacier Changes

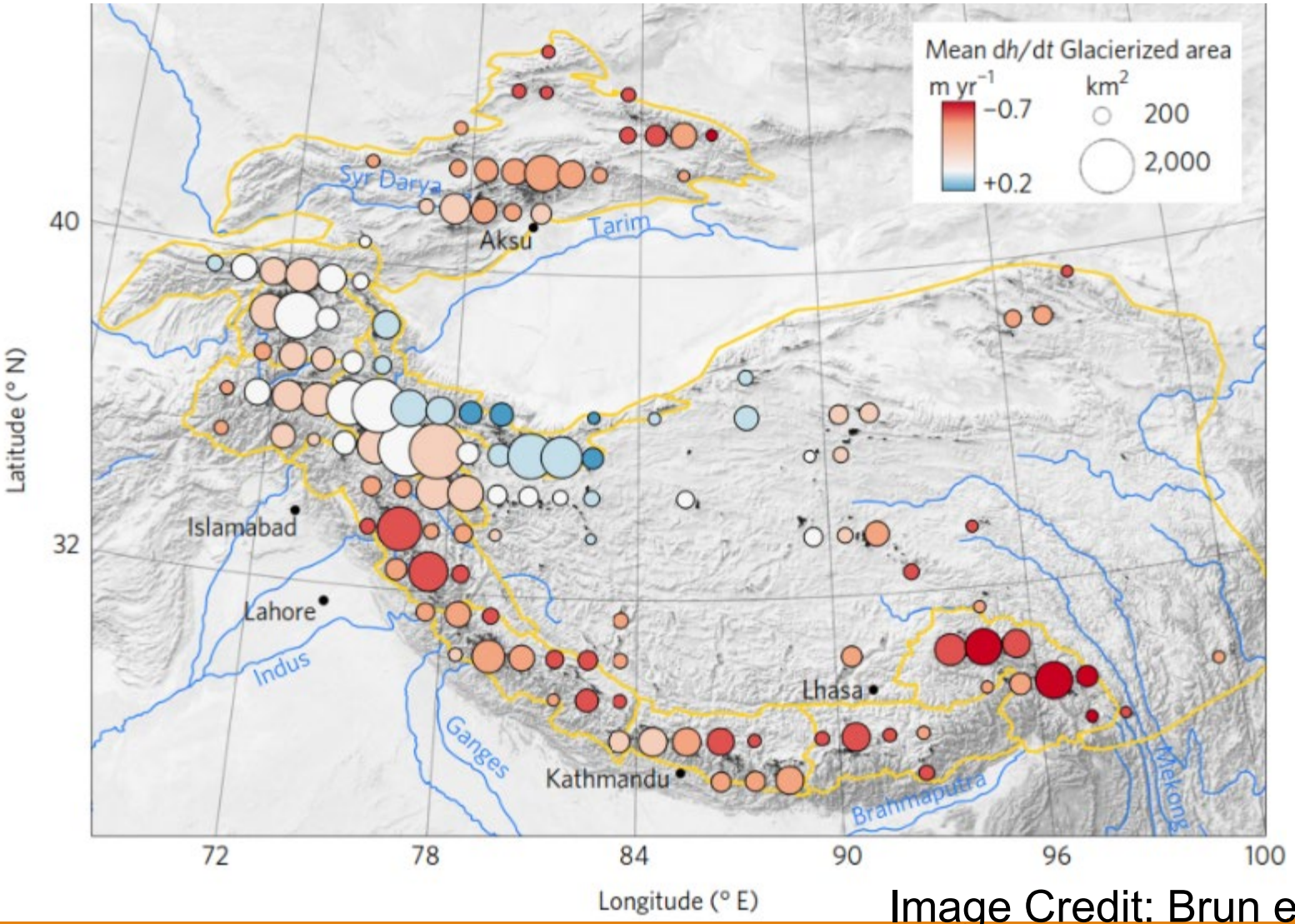


Image Credit: Brun et al., 2017

Himalayan glaciers: Conclusions

Snowmelt onset and end dates are occurring earlier in the year, in the context of overall glacier shrinkage and warming of the earth.

Snowmelt period (e.g., how long snow takes to melt off) is shrinking, about a 3-week shift in snowmelt onset and end dates.

Trends show less snow, melting earlier and faster. The future: (a) run out of water earlier in the year (intermittent droughts) & (b) more early-season floods (rain falls on snow).

Rainfall may be increasing, so the overall amount of water is less critical than the TIMING changing markedly, reducing water consistency for planting, harvesting, drinking water, & hydropower.

>1 billion people will be affected: Indus, Ganges/Brahmaputra, and Mekong River basins

1. Smith T, Bookhagen B. Changes in seasonal snow water equivalent distribution in High Mountain Asia (1987 to 2009). *Sci Adv* 2018
2. Smith T, Bookhagen B. Chapter 8. Remotely Sensed Rain and Snowfall in the Himalaya. In: Dimri AP, et al. (eds.), *Himalayan Weather and Climate and their Impact on the Environment*. Basel: Springer. 2020: pp. 119-39.

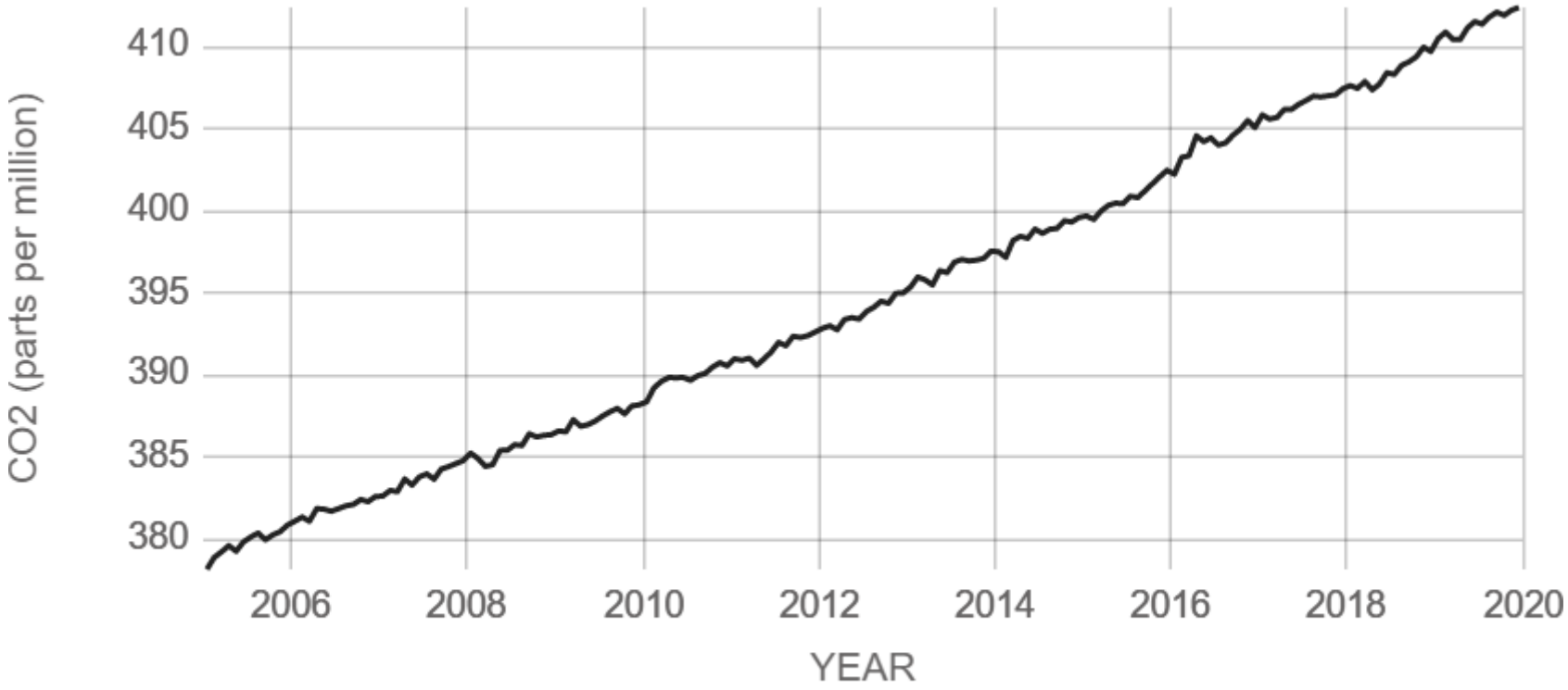
Research, Policy, Education, Action

Global Climate Change
Loss of Biodiversity
Overpopulation

Climate Change and Health: 2020-21 Events

- Australian and Western USA Wildfires
  - Smoke exposure and poor air quality
  - Mental health impacts
- Temperature Records
  - "Hottest day ever" records broken all over the world, from Siberia to Arizona
  - 2020 the hottest year in recorded history, along with 2016
- COVID-19
  - Impacts on CO^2 emissions were favorable
  - Food supply chain impacts were complex

CO2 trends from 2006-2020



Source: climate.nasa.gov

Global, National, Local Policy/Action to stabilize CO2 Atmospheric Levels

- Efficient Transportation
- Energy Conservation
- Sustainable Energy Sources
- Sustainable Land Use
- Population Stabilization
- Economic incentives (cap and trade; carbon credits)
- Political change and commitment
  - Moratorium on fossil fuel exploration
  - Massive shift to alternative energy sources
  - Commitment to conservation, e.g., mass transit, LEED buildings, policy shifts (68ºF. in winter, 72ºF. in summer)

Mitigation

- Emergency responses and planning
  - Heat waves, drought, extreme weather
  - Flooding refugee relocations
- Anticipatory work
  - Ocean barriers
  - Air cooling/hydration planning for vulnerable populations
  - Prior relocations
  - Re-forestation, not de-forestation
  - Control of air and water pollution
- Vector control; water and hygiene
- Making contraception available to meet unmet needs

CNN World - Kids around the world plan to skip school this Friday to demand action on climate change

Live TV U.S. Edition

Kids around the world plan to skip school this Friday to demand action on climate change

By Harmeet Kaur, CNN
Updated 6:32 AM ET, Wed March 13, 2019

More from CNN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A Texas couple has been sentenced to 7 years in prison for...

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By Jack Kramer, CTNewsJunkie.com Updated 8:03 am EDT, Friday, April 19, 2019

Divestment protesters to appear before ExComm

ASHA PRIHAR & CARLY WANNA | 1:38 AM, APR 22, 2019
STAFF REPORTERS

Reuben Ng

Policy/Action to stabilize CO_2 Atmospheric Levels

- Efficient Transportation
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- Economic incentives (cap and trade; carbon credits)
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  - Massive shift to alternative energy sources
  - Commitment to conservation, e.g., mass transit, LEED buildings, policy shifts (68°F./20°C. in winter, 72°F./22°C. in summer)
- Research into carbon capture

Mitigation

- Emergency responses and planning
  - Heat waves, drought, extreme weather
  - Flooding refugee relocations
- Anticipatory work
  - Ocean barriers and/or coastal relocations to create tidal flood plains
  - Air cooling/hydration planning for vulnerable populations (infants, aged)
  - Re-forestation, not de-forestation
  - Water management and relocations
  - Control of air and water pollution
- Vector control; water and hygiene challenges
  - Desertification and drought/flood cycles
- Family planning to meet unmet needs

Why don't the politicians reflect the views of a majority of the people?

- Campaign donations and lobbying by the fossil fuel industry
  - Documented by The Center for Responsive Politics https://www.opensecrets.org/industries/indus.php?ind=e01

- Data for donations from oil and gas companies to the Trump-Clinton presidential election cycle released by Federal Election Commission on April 16, 2016
  - Highest donors, by far: Koch Industries

Yale Program on Healthcare Environmental Sustainability

- Mission: To develop and support efforts that measure, mitigate, and adapt to pollution, **uniquely focusing on healthcare delivery.**

- **Interdisciplinary** collaboration between:
  - Healthcare professionals; Bioinformatics scientists
  - Sustainability scientists and engineers; Entrepreneurs and innovators
  - Health economists; Public policy and legal experts
  - Business management and healthcare administrators

Y-PHES Vision: ***To lead the transformation of the healthcare sector to a sustainable, circular economy, in alignment with the U.N. Sustainable Development Goals.***

Scientific Research	Policy Research	Education
Patient-oriented	Eliminating excessive waste/pollution	Curriculum development
Life cycle assessment	Infection control vs. public health	Mitigation
Green engineering/ sustainable design	Single use > circular life cycle	Adaptation
Bioinformatics, procurement, facilities data	Performance metrics/incentives • Pay-for-performance • Resource consumption • Environmental emissions • Cost	Disaster preparedness
Alternative clinical pathways		
Reusable vs. disposable device management		
Pharmaceuticals	Patient outcomes	
Compare high/mid/low-resource nations; adopt best practices		

Strategic Development Goals for 2030

Online climate change & health certificate program

- First online certificate program on this topic offered by a US school of public health
- Blends convenience of working independently with real-time online interactions with faculty and peers
- Three Courses--18 weeks
- Learners from around the world
  - https://ysph.yale.edu/climate
- Climate change and health concentration in our MPH program since 2019

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