# Mitigating Climate, Meeting MDGs, and Moderating Chronic Diseases: The Health Co-benefits Landscape

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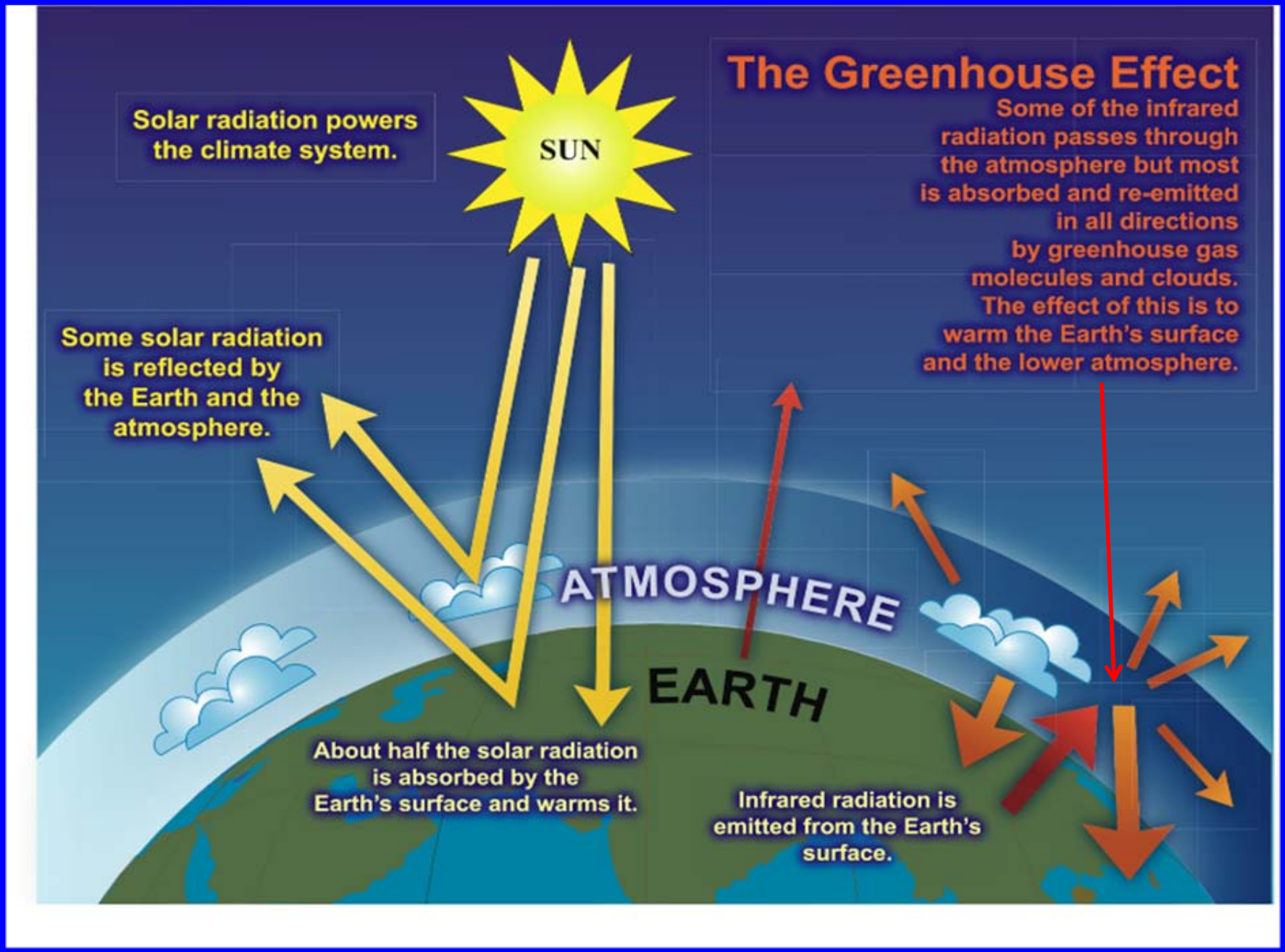
From: Kirk R. Smith and Kalpana Balakrishnan,

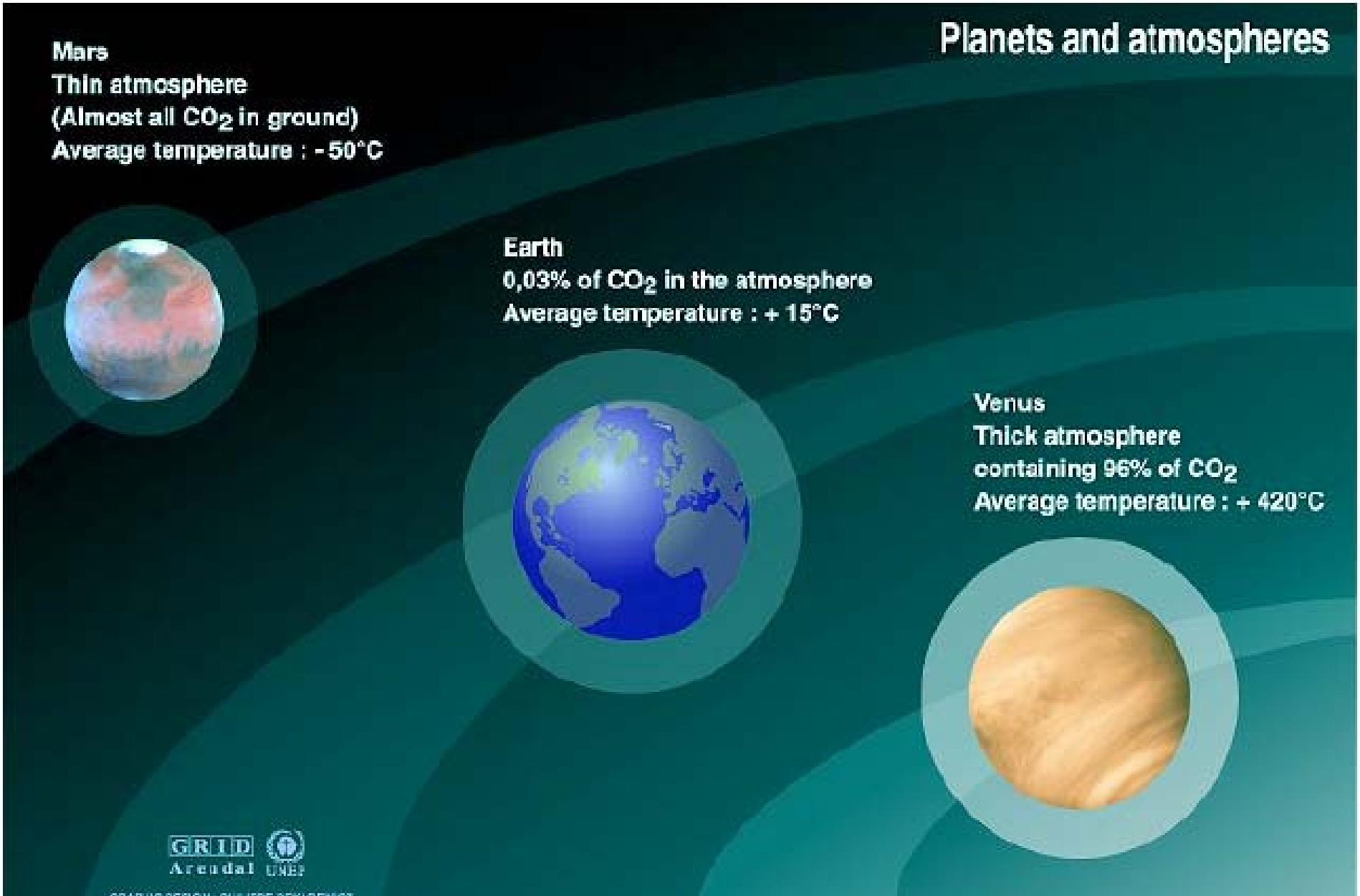
Mitigating Climate, Meeting MDGs*, and Moderating Chronic Diseases: The Health Co-benefits Landscape

*Millennium Development Goals

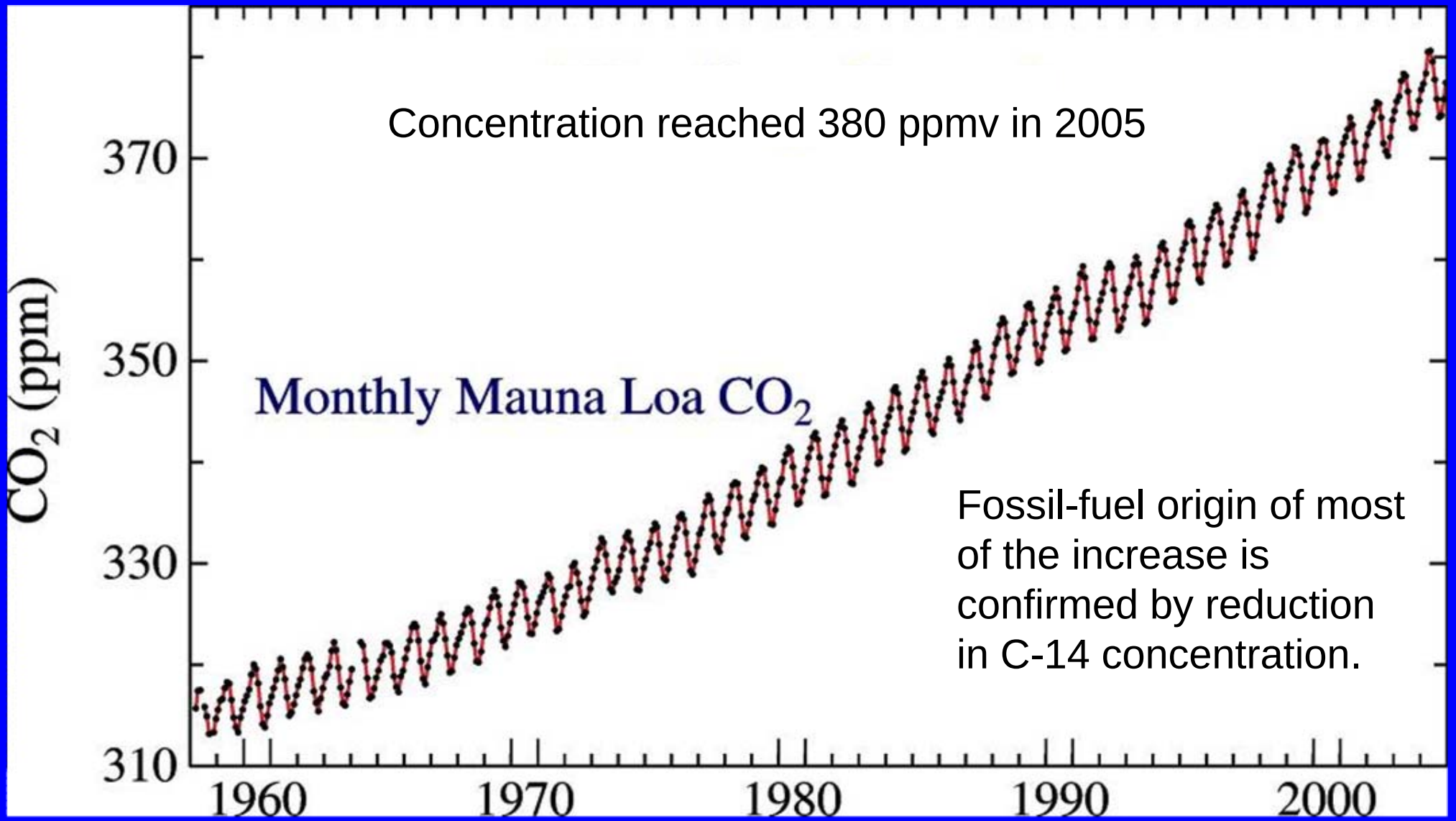
Chapter 4, Commonwealth Health Ministers' Update, Commonwealth Secretariat, London, pp. 59-65, 2009.


The Greenhouse Effect
Some of the infrared radiation passes through the atmosphere but most is absorbed and re-emitted in all directions by greenhouse gas molecules and clouds. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation powers the climate system.
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
ATMOSPHERE
EARTH
About half the solar radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

# There's no place I'd rather be



# Direct measurements of $CO_2$ show continued rise




Atmospheric $CO_2$ measured at Mauna Loa, Hawaii.

*Source: NOAA Climate Monitoring and Diagnostic Laboratory*

Atmospheric Greenhouse gas concentrations

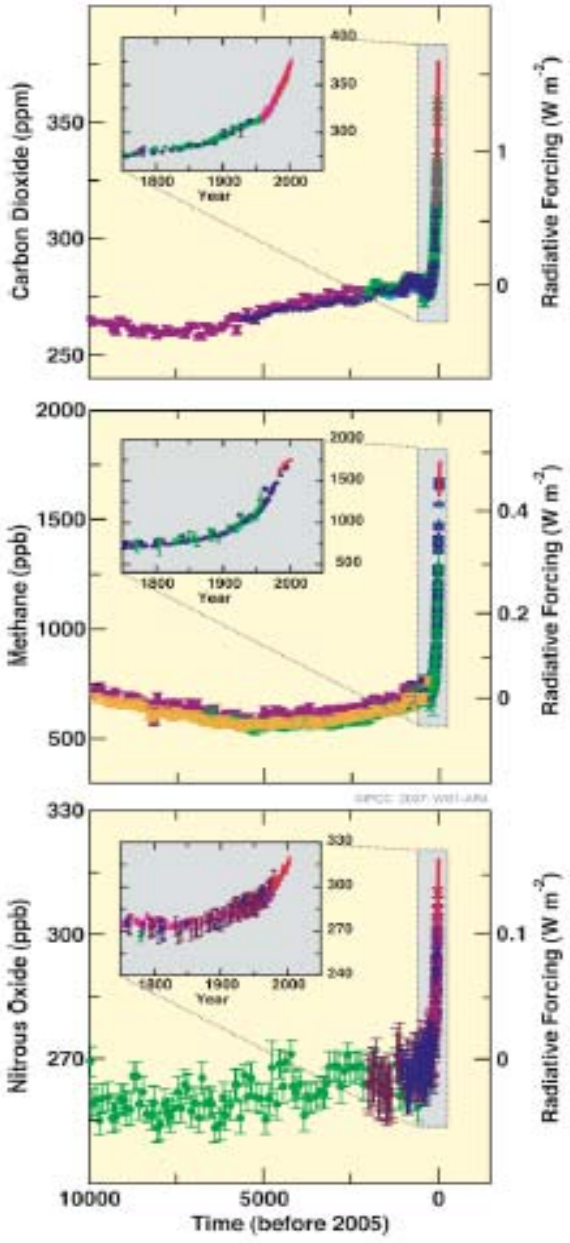



Figure SPM.1
IPCC 2007

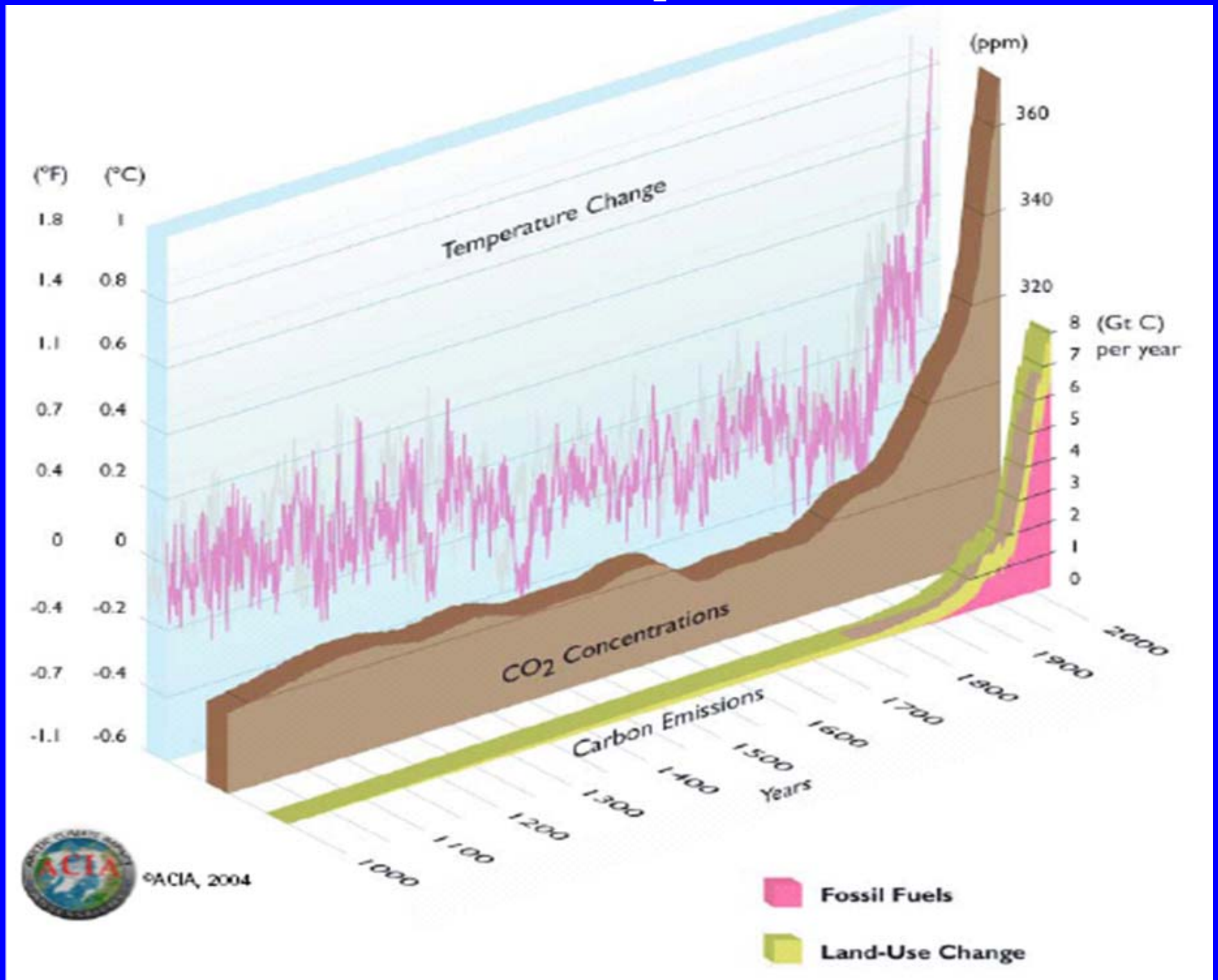
**Anthropogenic Sources**

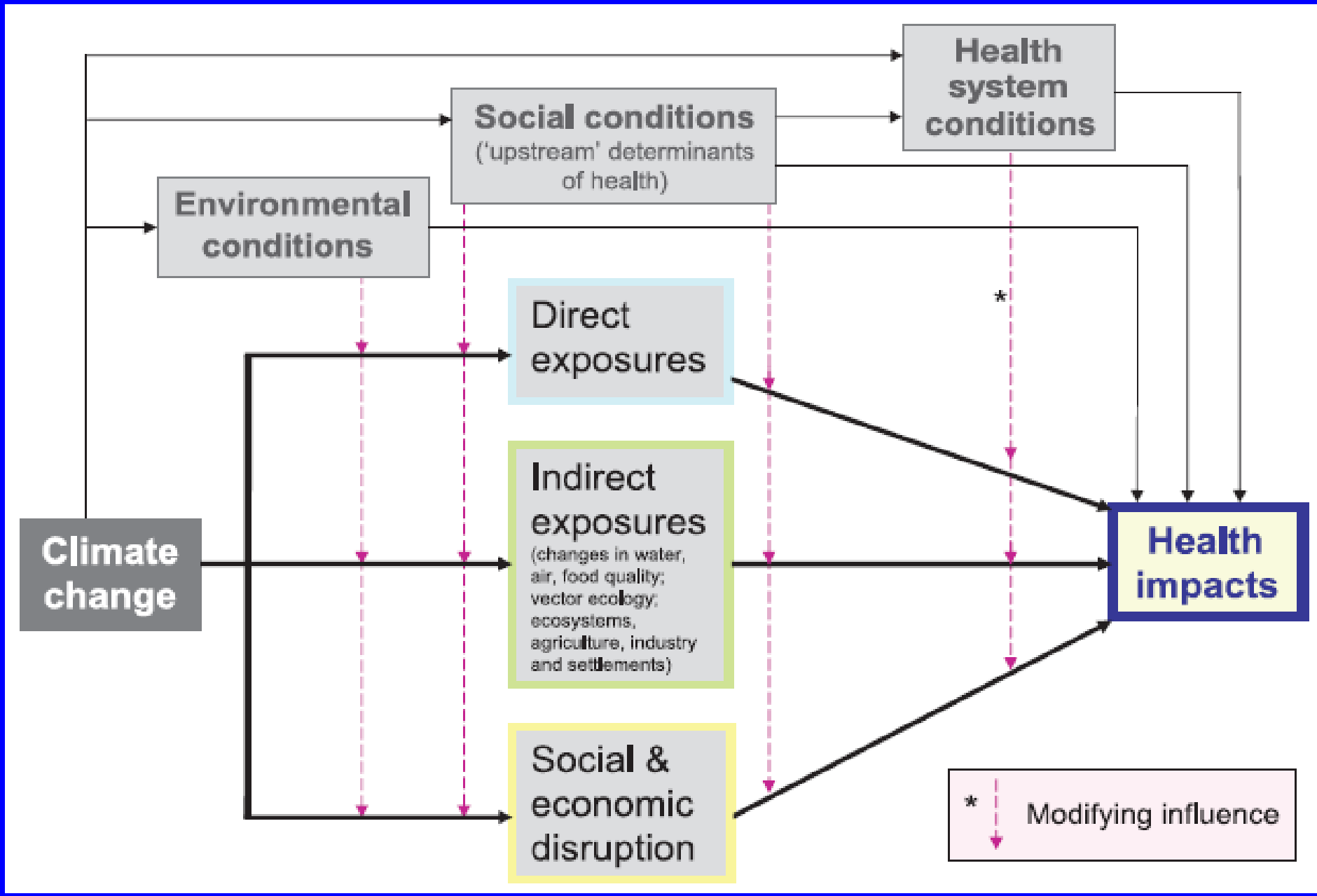
**$CO_2$**
Fossil fuels
Land use change
Cement manufacturing

**Methane**
Landfills
Rice
Livestock
Waste management
Fossil recovery

**$N_2O$**
Fertilizer
Planted N-fixers
Combustion

# 1000 years of global C emissions, $CO_2$ concentrations, and temperature






IPCC WGII, 2007

# Categories of Health Impacts

1) **Direct impacts** through changing weather patterns (e.g., storms, floods, temperature extremes)
2) **Indirect impacts** through natural systems including changes in water supply and quality, air pollution, and ecosystems leading to shifts in disease vectors.
3) **Systemic impacts** operating through human systems including shifts in food supplies, refugee patterns, coastal and agricultural livelihoods, and the health impacts of society's responses to climate change, such as geo-engineering, carbon taxes, biofuel production, etc.
4) **Low-probability high-consequence impacts** such as extremely rapid climate change or sea level rise due to threshold phenomena in Earth's systems, e.g., runaway methane emissions from the tundra or rapid loss of parts of the Antarctic ice sheet.
5) **Co-benefits**: Achieving health- and climate-protection benefits with the same policies and projects

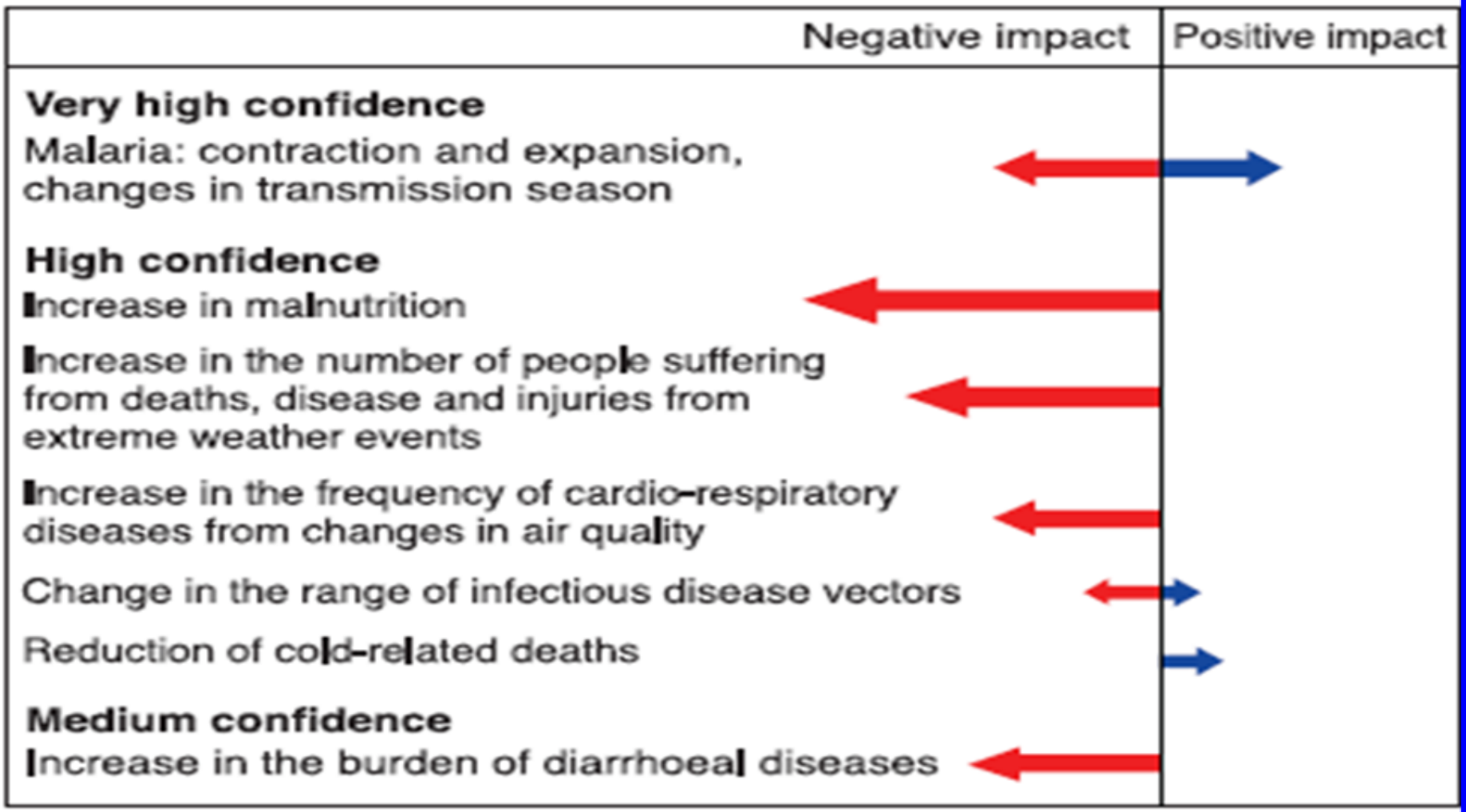


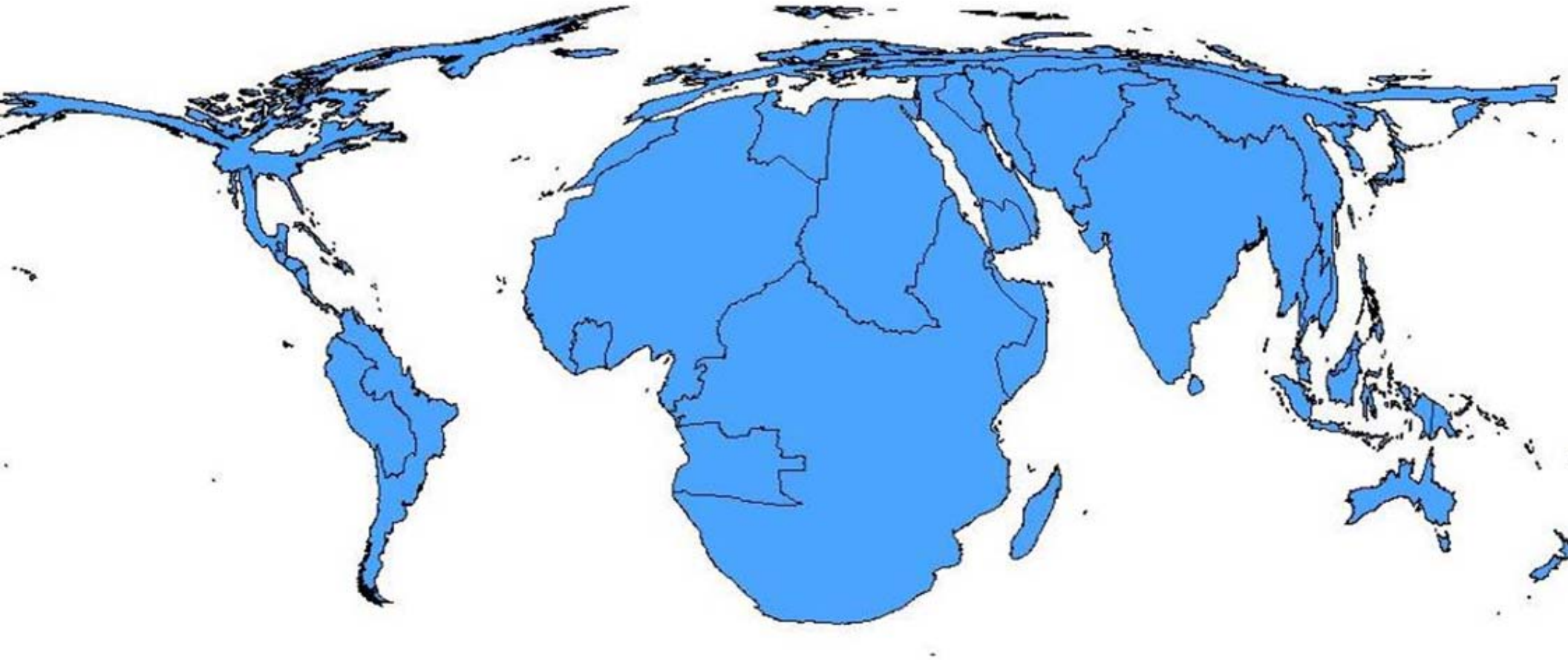

**Figure 8.3.** *Direction and magnitude of change of selected health impacts of climate change (confidence levels are assigned based on the IPCC guidelines on uncertainty, see http://www.ipcc.ch/activity/uncertaintyguidancenote.pdf).*

IPCC WGII, 2007

# WHO Comparative Risk Assessment – 2004 Climate Change

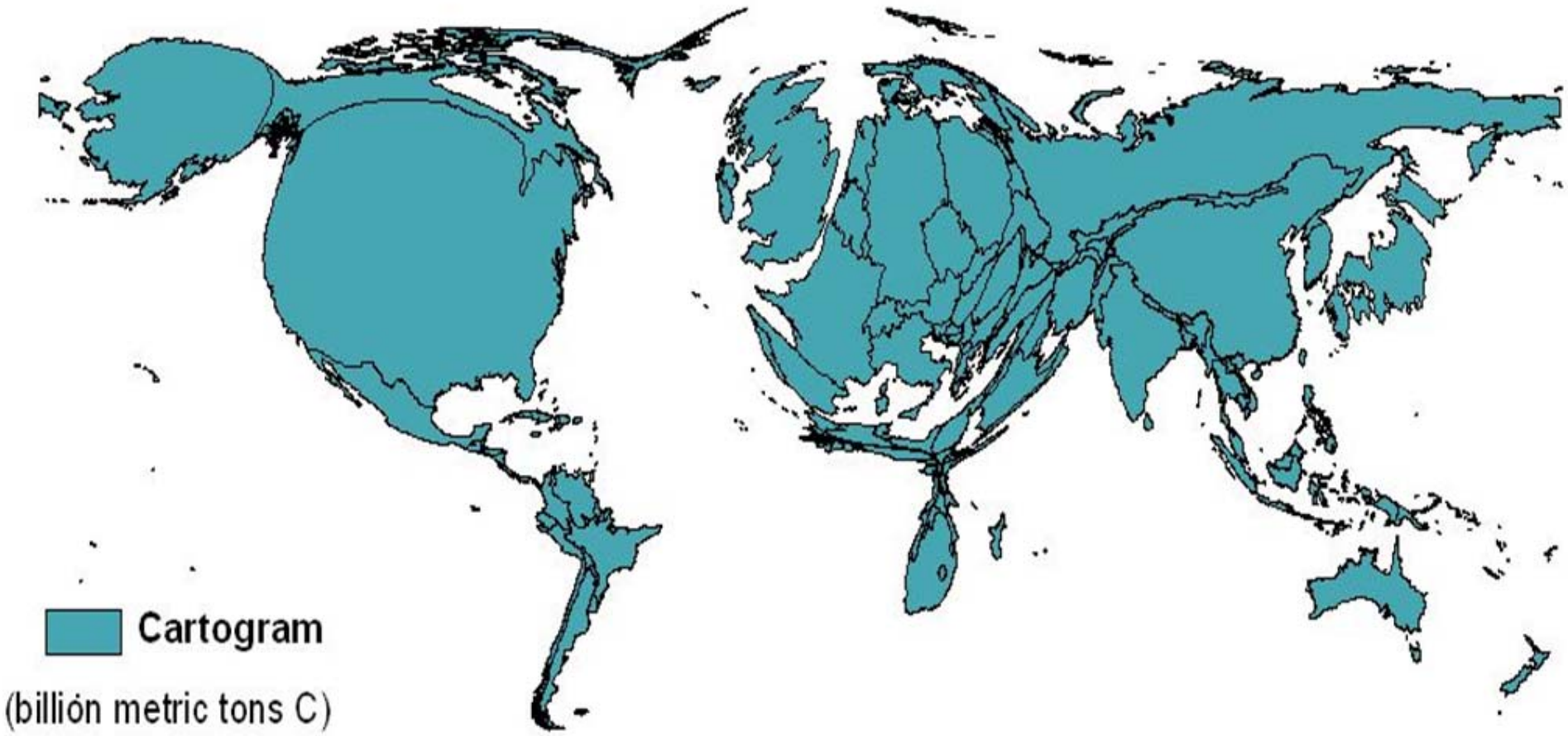
- Diarrhea – 2.4% of global burden
- Malaria – 2%; 6% in some regions
- 17% of protein-energy malnutrition
- 7% of dengue fever in some rich countries
- 150,000 premature deaths, 99% in poor countries (46% in South Asia)
- 0.4% of all DALYs
- Most (88%) of impact in children under 5

# Cartogram of Climate-related Mortality (per million pop) yr. 2000



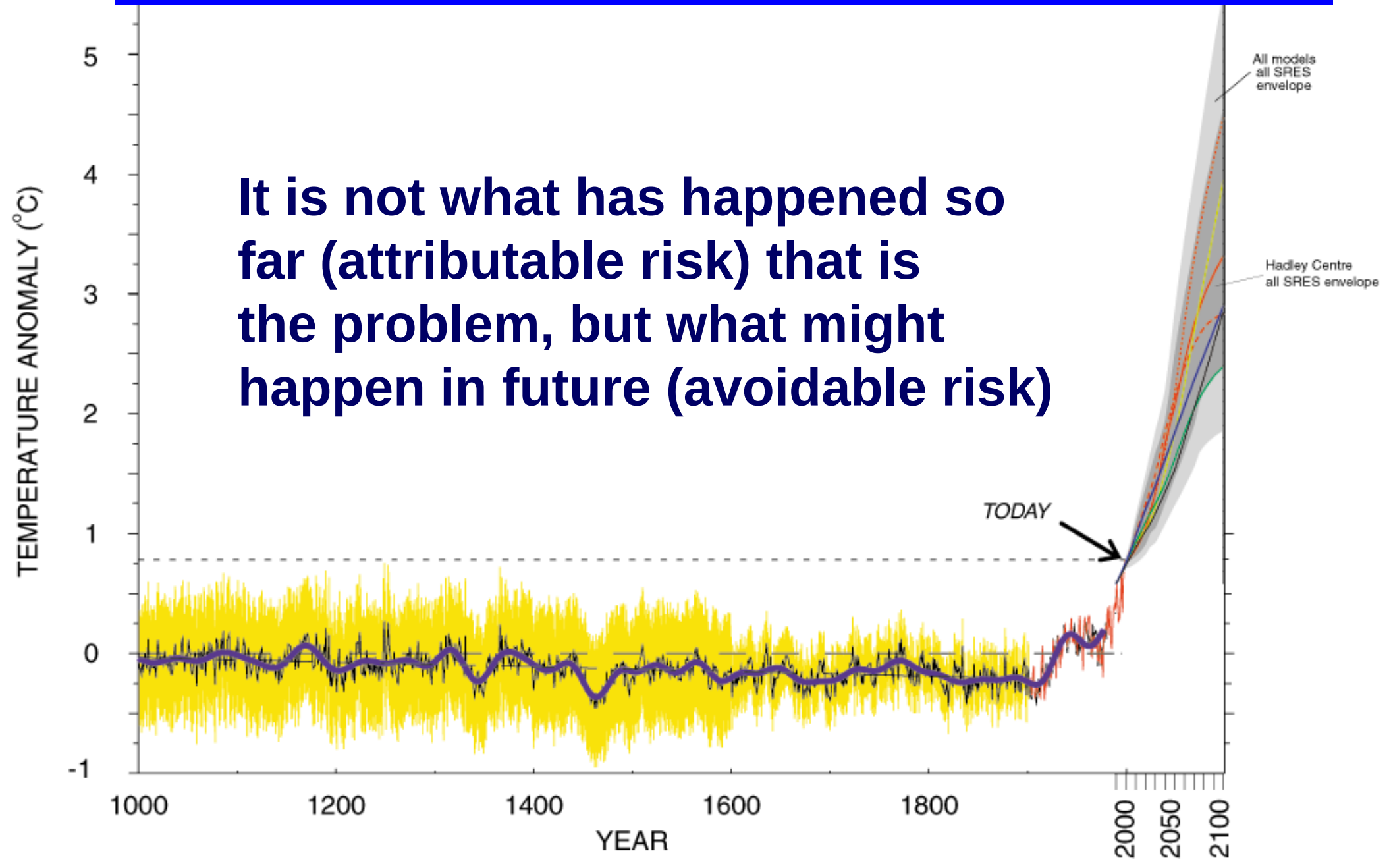
Data from the WHO Comparative Risk Assessment, 2004

# Cumulative $CO_2$ emissions from fossil fuels (as depleted by natural processes)




Patz JA, Gibbs HK, Foley JA, Rogers JV, Smith KR, 2007, **Climate change and global health: Quantifying a growing ethical crisis**, EcoHealth 4(4): 397–405, 2007.

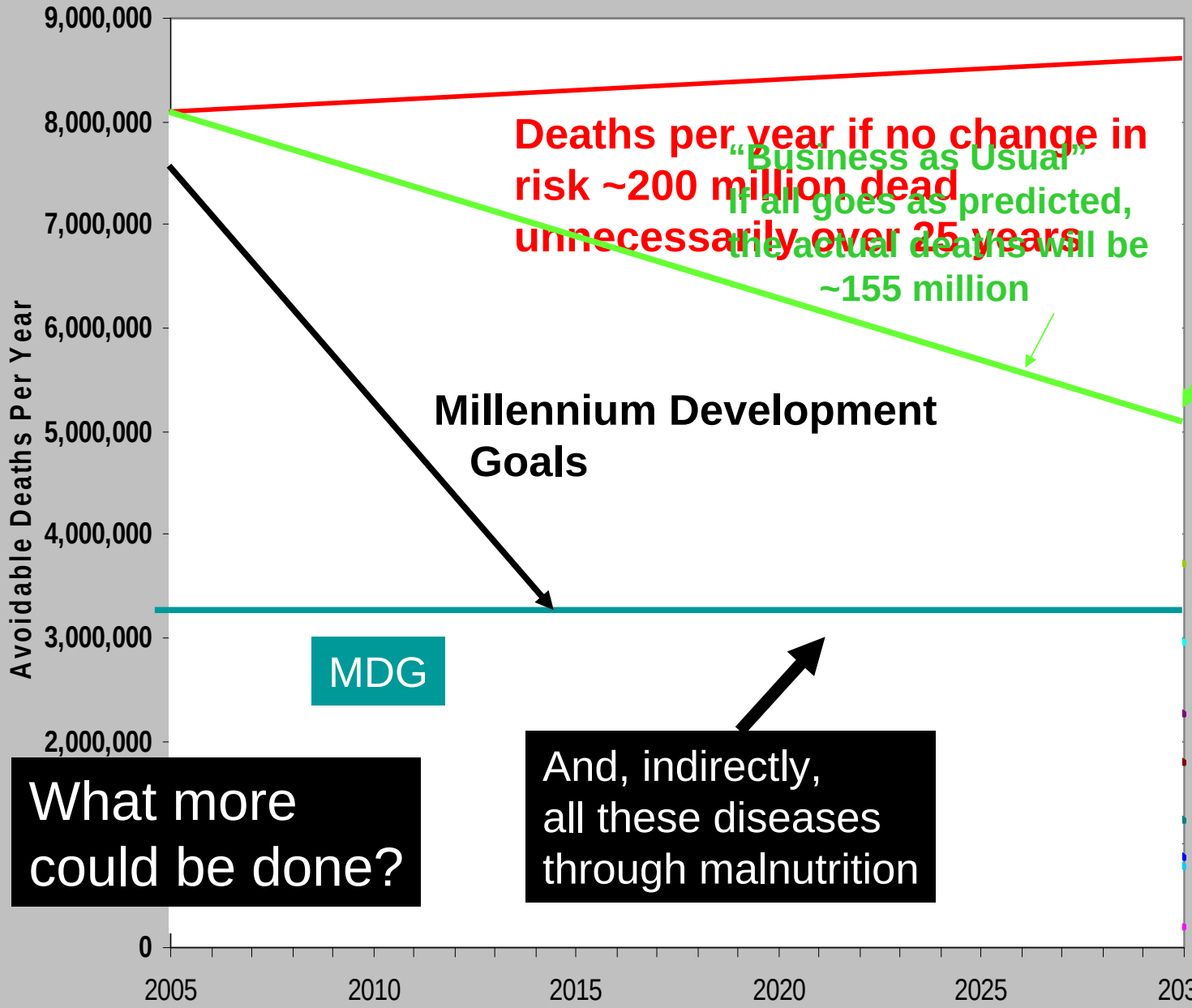
# 1000 years of Earth temperature history…and 100 years of projection




**It is not what has happened so far (attributable risk) that is the problem, but what might happen in future (avoidable risk)**

# Child Mortality Wedges: 2005-2030

Children in the poorest nations with 2.7 billion people: <$750/year-person




Climate change directly affects

- Perinatal = 1.4 million/y
- ARI = 0.8 million/y
- Diarrhea = 0.7 million/y
- Vaccines = 0.5 million/y
- Malaria = 0.6 million/y
- Chronic Diseases = 0.4 million/y
- HIV = 90 thousand/y
- Unavoidable Deaths = 0.2 million/y

# Co-benefits: Being Smart about Mitigation

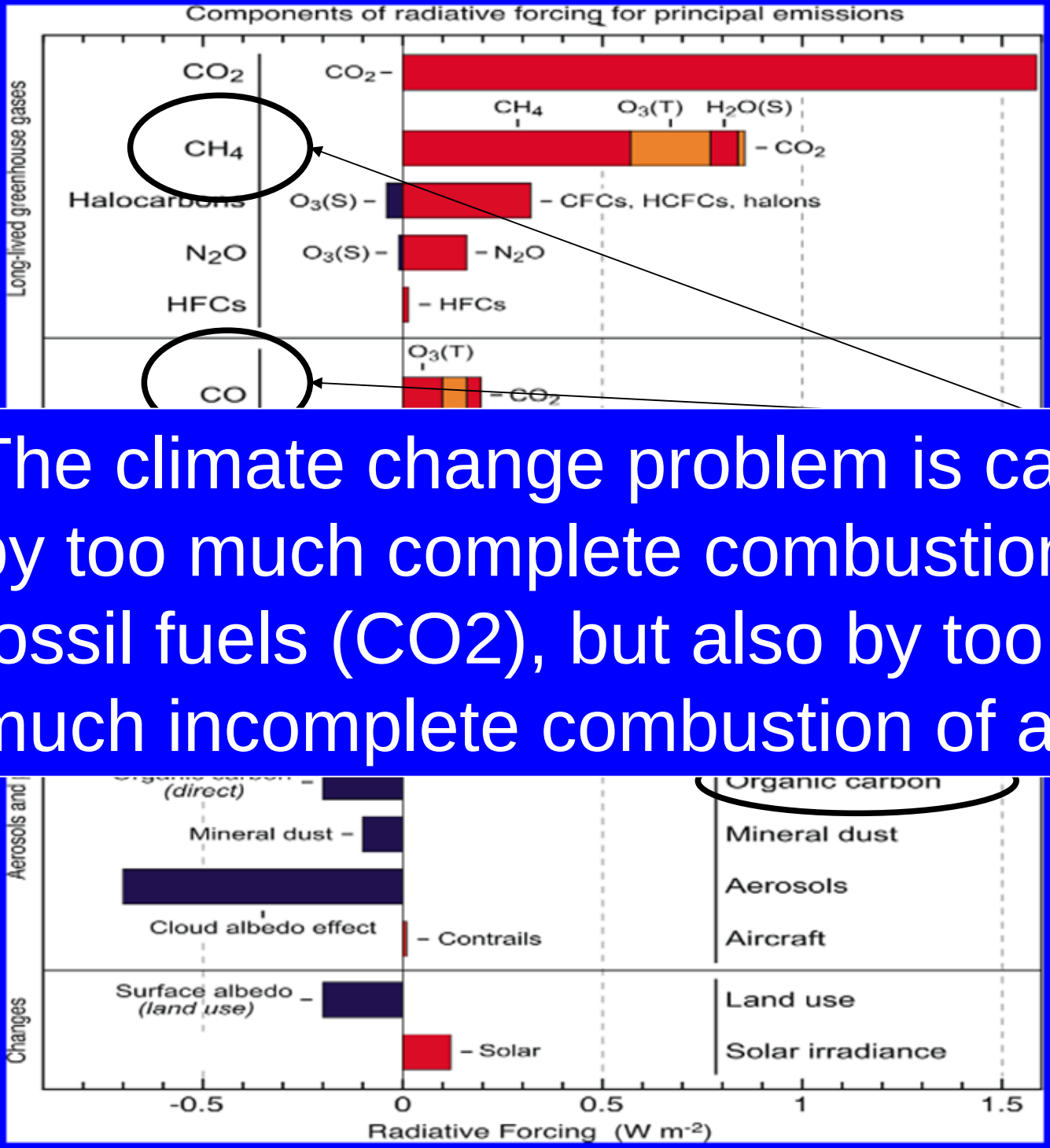
- **Link with broader society**: Guide mitigation measures so they help achieve other important societal goals, including health protection.
- **Spread costs**: Helps reduce the cost of mitigation by sharing cost with other sectors.
- **No-regrets:** providing a short-term more certain return (health) on a long-term more uncertain investment (climate protection)
- **Political bridge** over the international divide between developed and developing countries

# Major Categories of Co-benefits

- There is no sector that does not have at least some relation to energy, health, and climate
- Here, however, are listed examples only in sectors that have potentially significant positive impacts on health and climate protection.
- I do not include climate mitigation measures that may have significant negative impacts on health, such as promoting biofuels from agricultural land, etc.

# Air Pollution from Energy Use

- Household solid fuels
  - Large source of ill-health worldwide in poorest populations – 1.6 million premature deaths
  - Non-renewable biomass and coal carbon emissions
  - Poor combustion leads to non-CO2 GH-related emissions
- Outdoor emissions from energy systems
  - 0.8 million premature deaths
  - Most well documented benefits, climate and health
- Products of incomplete combustion are the most important points of interaction




**Warming in 2005 from emissions since 1750**

The climate change problem is caused not only by too much complete combustion of fossil fuels (CO2), but also by too much incomplete combustion of all fuels (PIC)

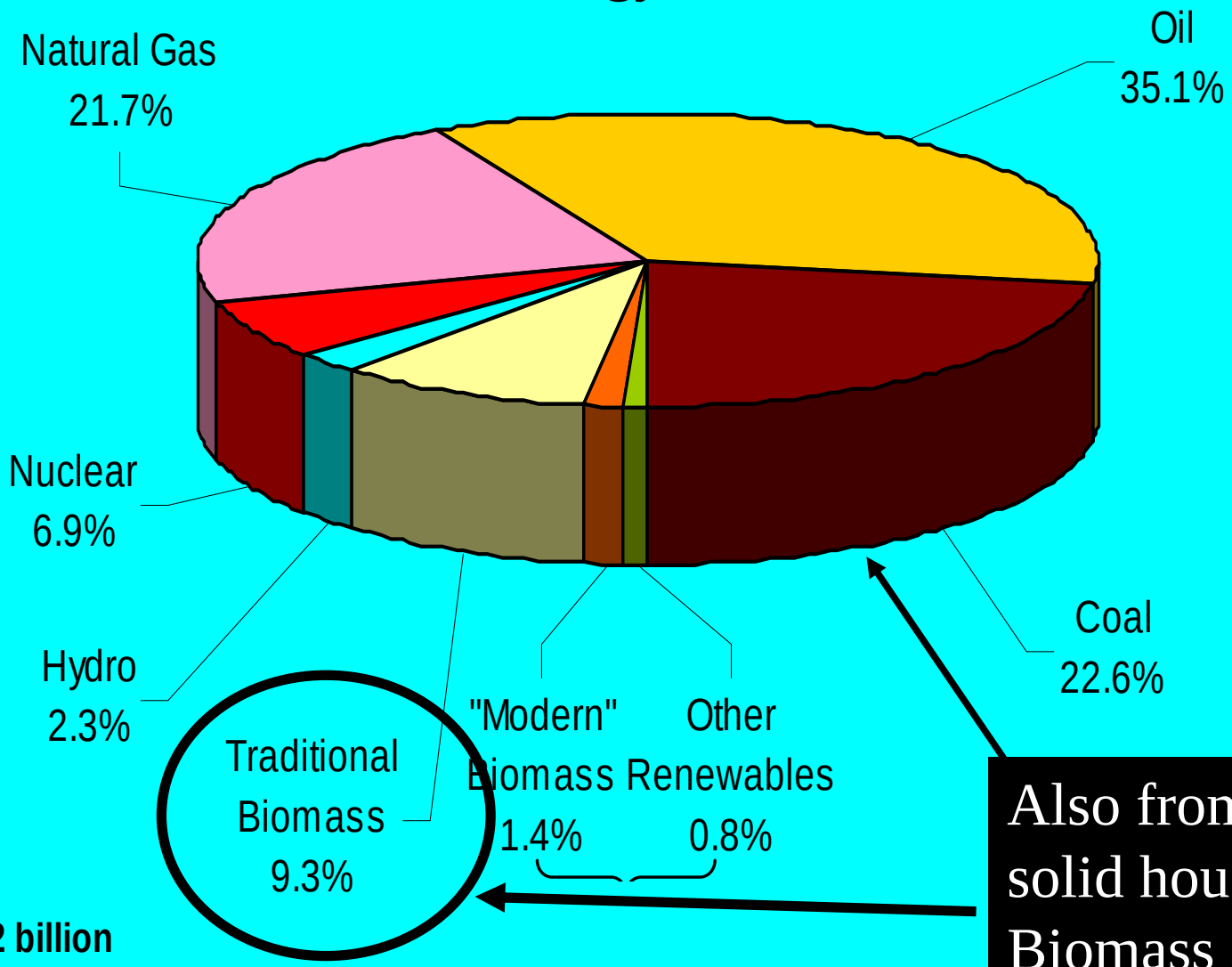
IPCC, 2007

Where do these PIC come from?

From forest and savannah fires – not directly human caused in general

Where else?

# World Energy – 2001




**Population: 6.102 billion**

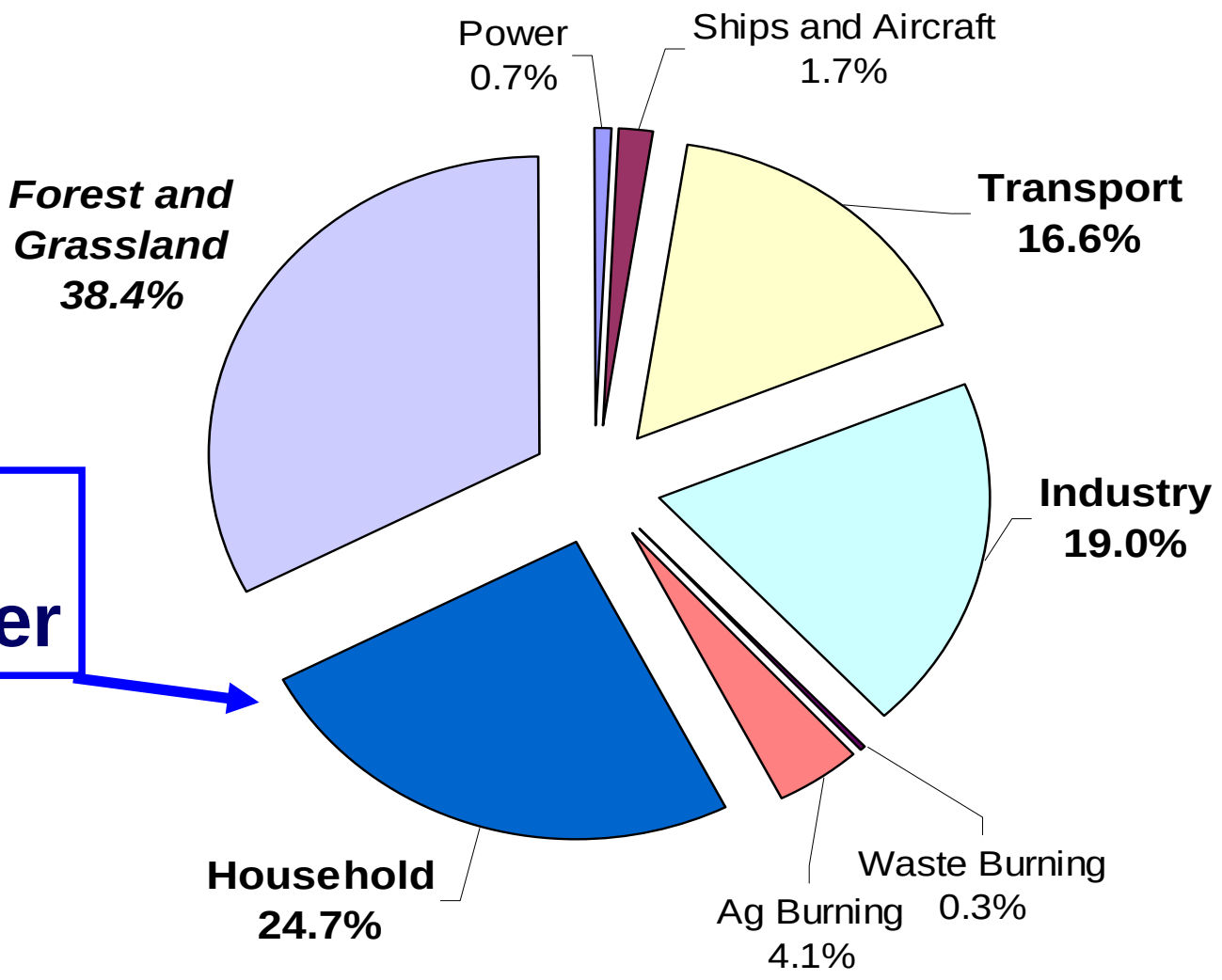
Total energy use: 10.2 Gtoe

Per capita energy consumption: 1.67 toe

World Energy Assessment, 2004

# Total Black Carbon Emissions in 2000

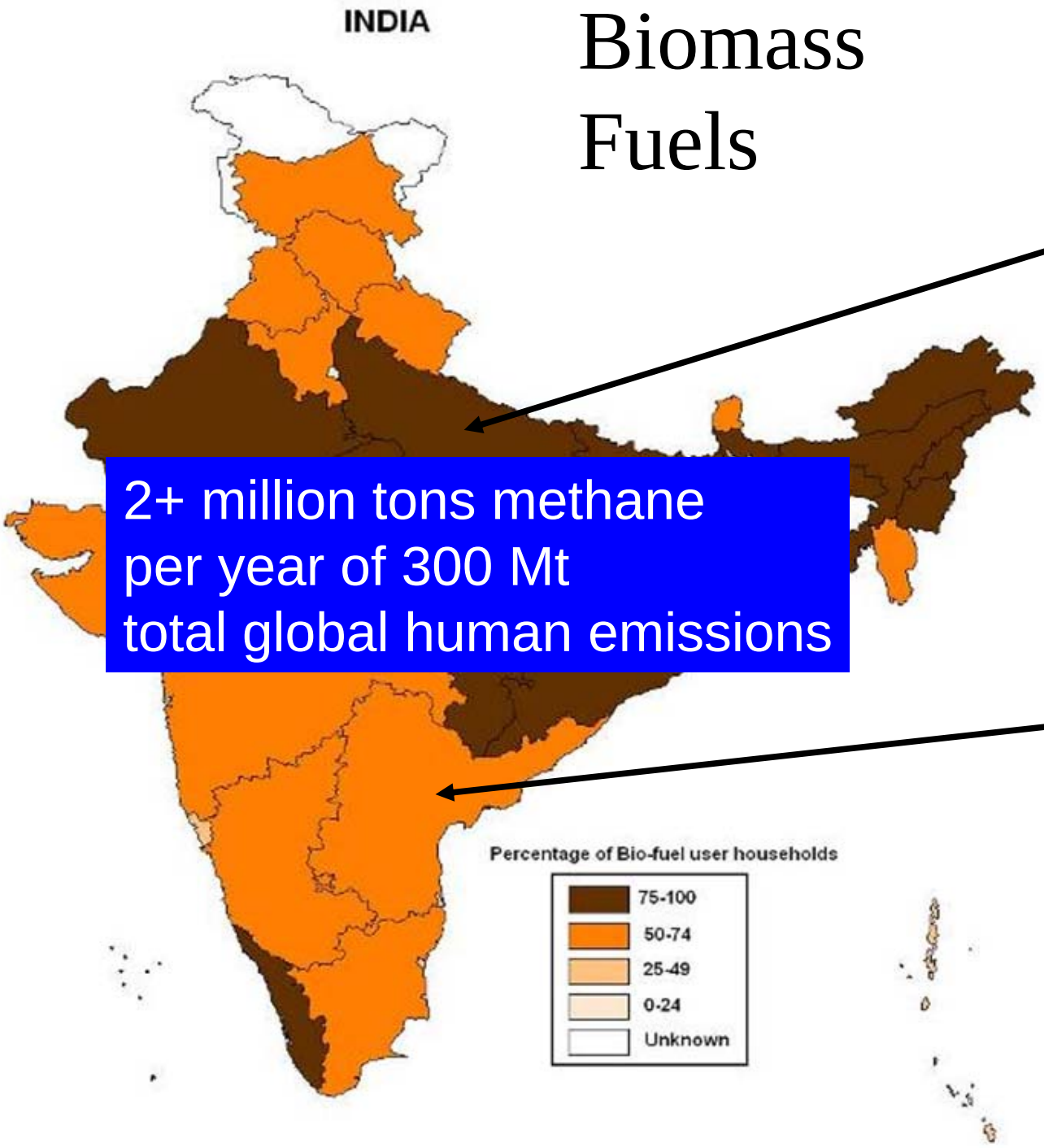
**Source: T Bond Database, V 7.1.1 Feb 2009**
**Plus Bond et al., 2004**




**India ~ 0ne-quarter**

Total: 7900 gigagrams

# Biomass Fuels



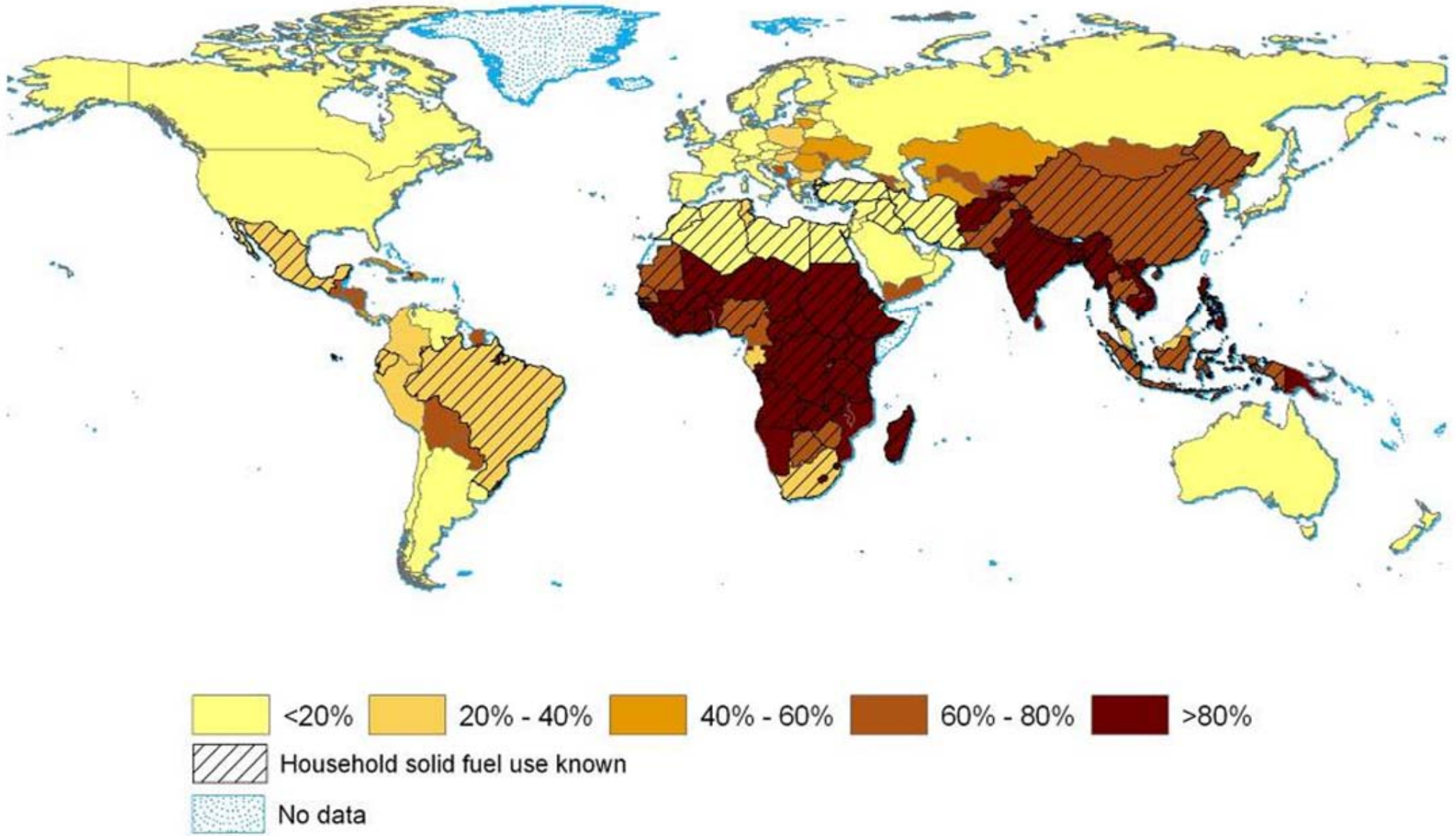

More than 75% of households

2+ million tons methane per year of 300 Mt total global human emissions

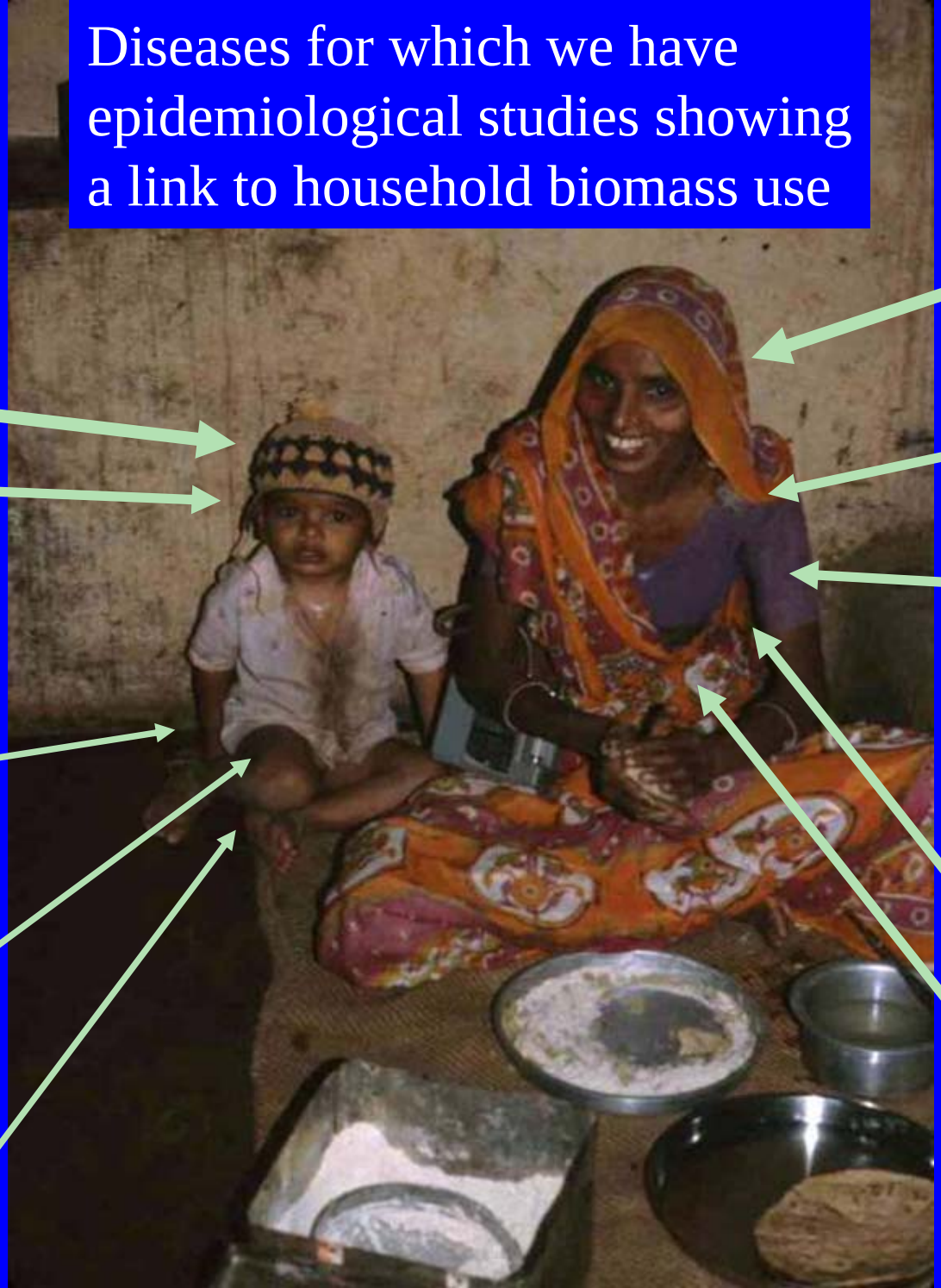
50-74% of households

2000 Census

# National Household Solid Fuel Use, 2000



Diseases for which we have epidemiological studies showing a link to household biomass use



ALRI/ Pneumonia (meningitis)

Low birth weight

Early infant death

Birth defects?

Cognitive Impairment?

Chronic obstructive lung disease

Blindness (cataracts)

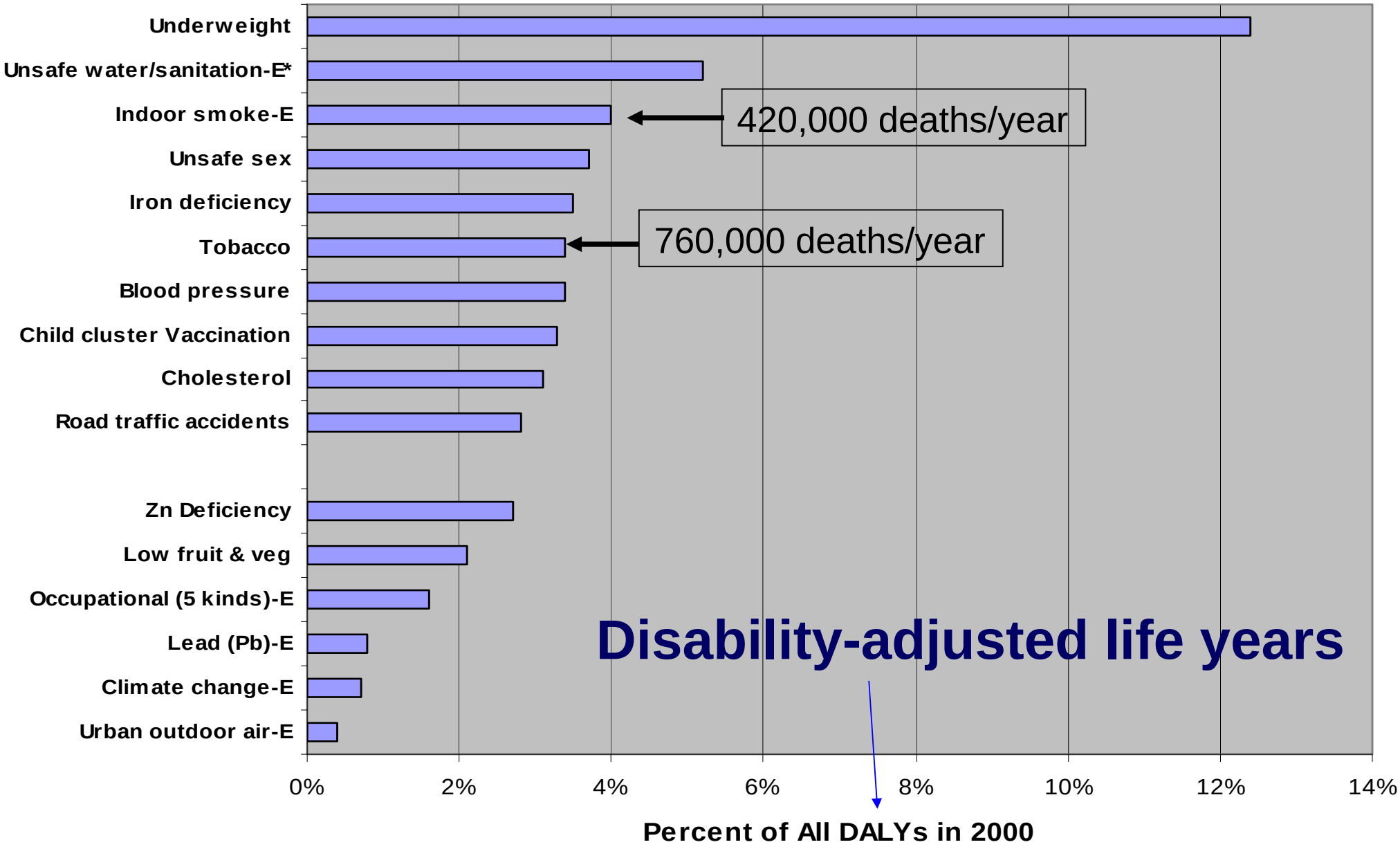
Cancer (lung)

Tuberculosis?

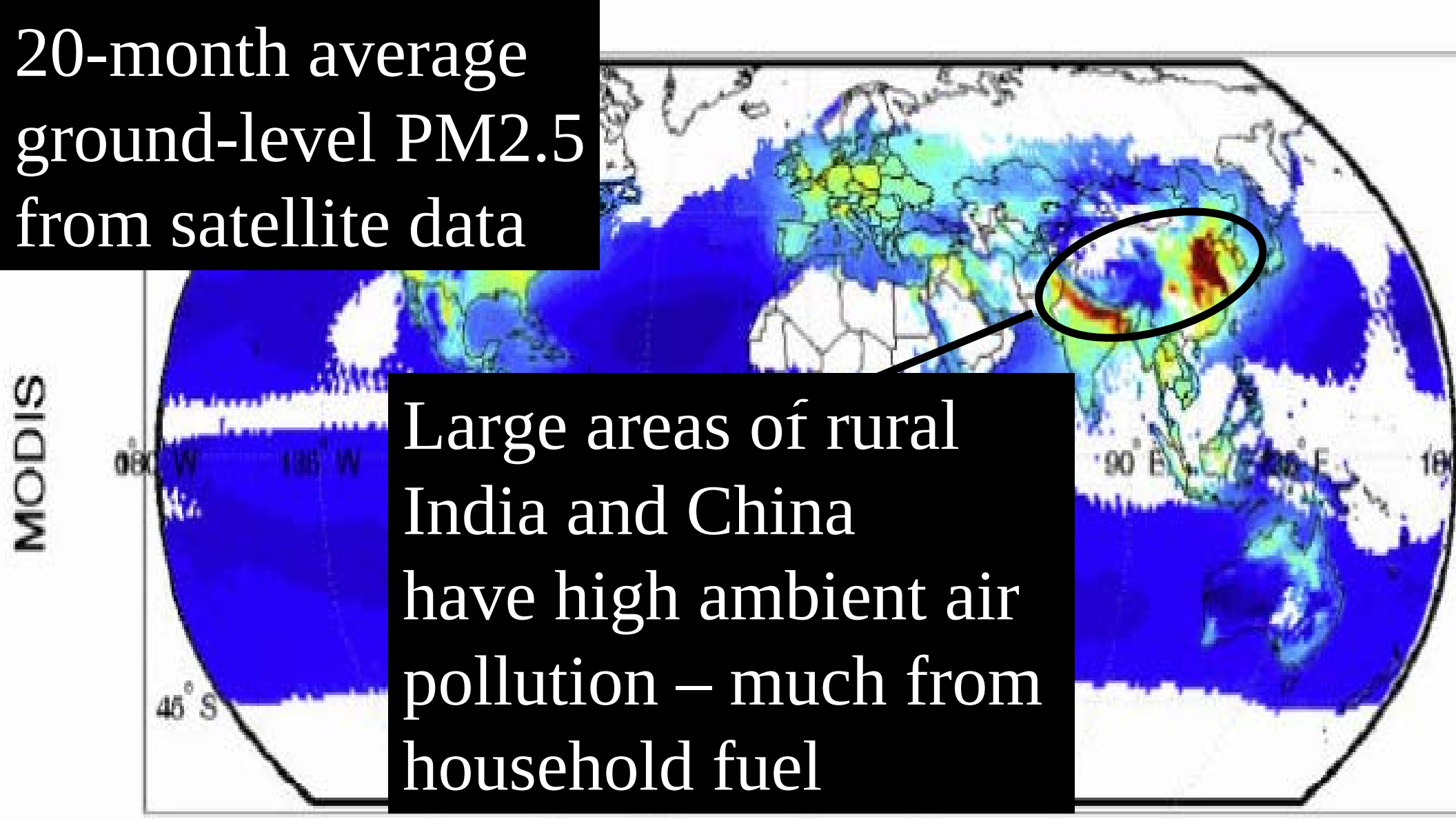
Heart disease?

# Indian Burden of Disease from Top 10 Risk Factors

## and Selected Other Risk Factors

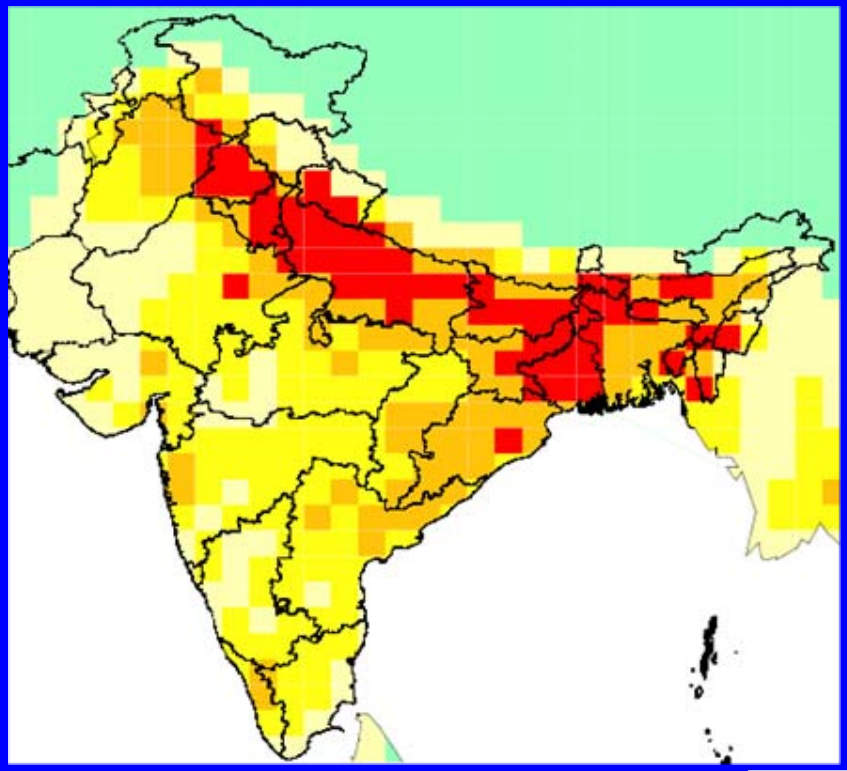


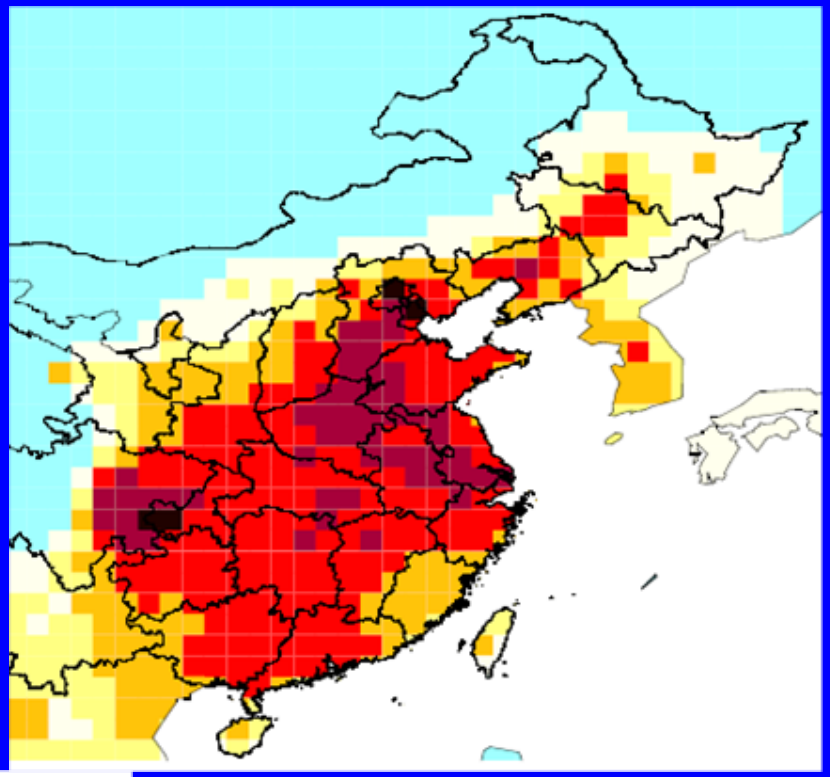
# 20-month average ground-level PM2.5 from satellite data




Large areas of rural India and China have high ambient air pollution – much from household fuel

# PM2.5 concentrations for 2000 computed with GAINS/TM5: Population-weighted annual mean concentrations (µg/m3)






$PM_{2.5}$ from anthropogenic primary PM emissions and secondary inorganic aerosols.

Natural sources are excluded!

Source: Markus Amman, IIASA

# Emissions attributable to household solid fuels in India

| Place | Year | PM2.5 | CH4 | CO2 | SO2 | NOx | N2O |
|---|---|---|---|---|---|---|---|
| **Andhra Pradesh** | 1990 | 15 | 4 | 7 | 11 | 9 | 2 |
| | 2005 | 40 | 4 | 2 | 4 | 5 | 2 |
| **Tamil Nadu** | 1990 | 15 | 5 | 0 | 1 | 4 | 2 |
| | 2005 | 24 | 4 | 0 | 0 | 1 | 1 |

Preliminary Results: December 8, 2009

# Modifying the Built Environment

- Obesity, traffic accidents, and lack of physical activity responsible for 3+ million additional premature deaths annually
- Reduce vehicle use (air pollution, obesity, safety, etc)
- Change urban design to increase physical activity (obesity, air pollution, safety)
- Improve energy efficiency of buildings (avoid health risks of energy poverty)

# Redirecting Diet Preferences

- Livestock responsible for 20+% of global greenhouse emissions – methane from animal digestion plus operation of meat/dairy feed/supply systems
- Converge on lower mean global red meat consumption
  - Suggested 90 g/d – Lancet 2007
  - Major health benefits: heart disease, stroke, obesity, bowel and breast cancer
- Similar benefits to convergence in global dairy consumption
- China/India have the major global growth potential

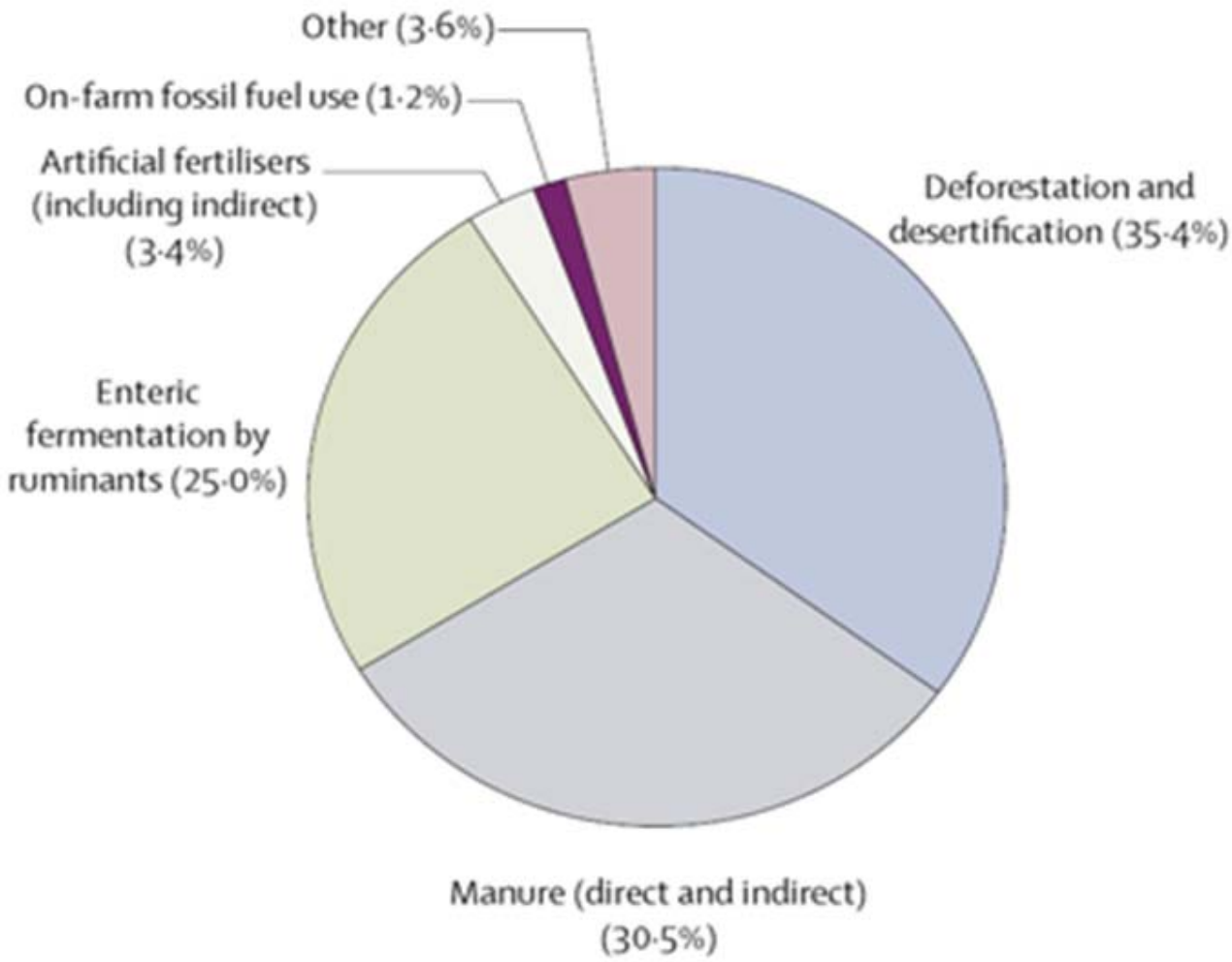
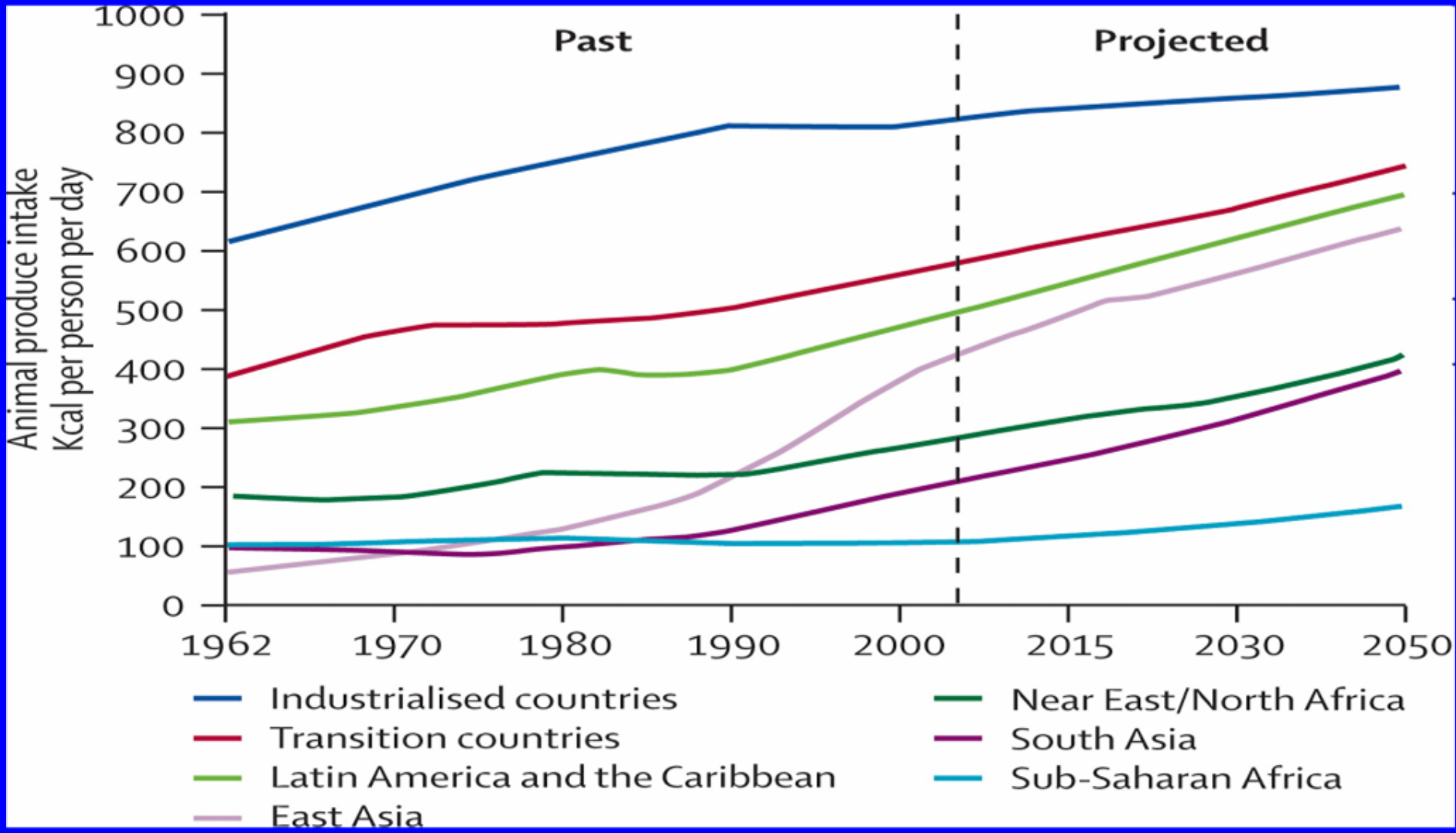



***Figure 2:*** **Proportion of greenhouse-gas emissions from different parts of livestock production**

Adapted from FAO.[42]

# Trends in consumption of livestock products per person



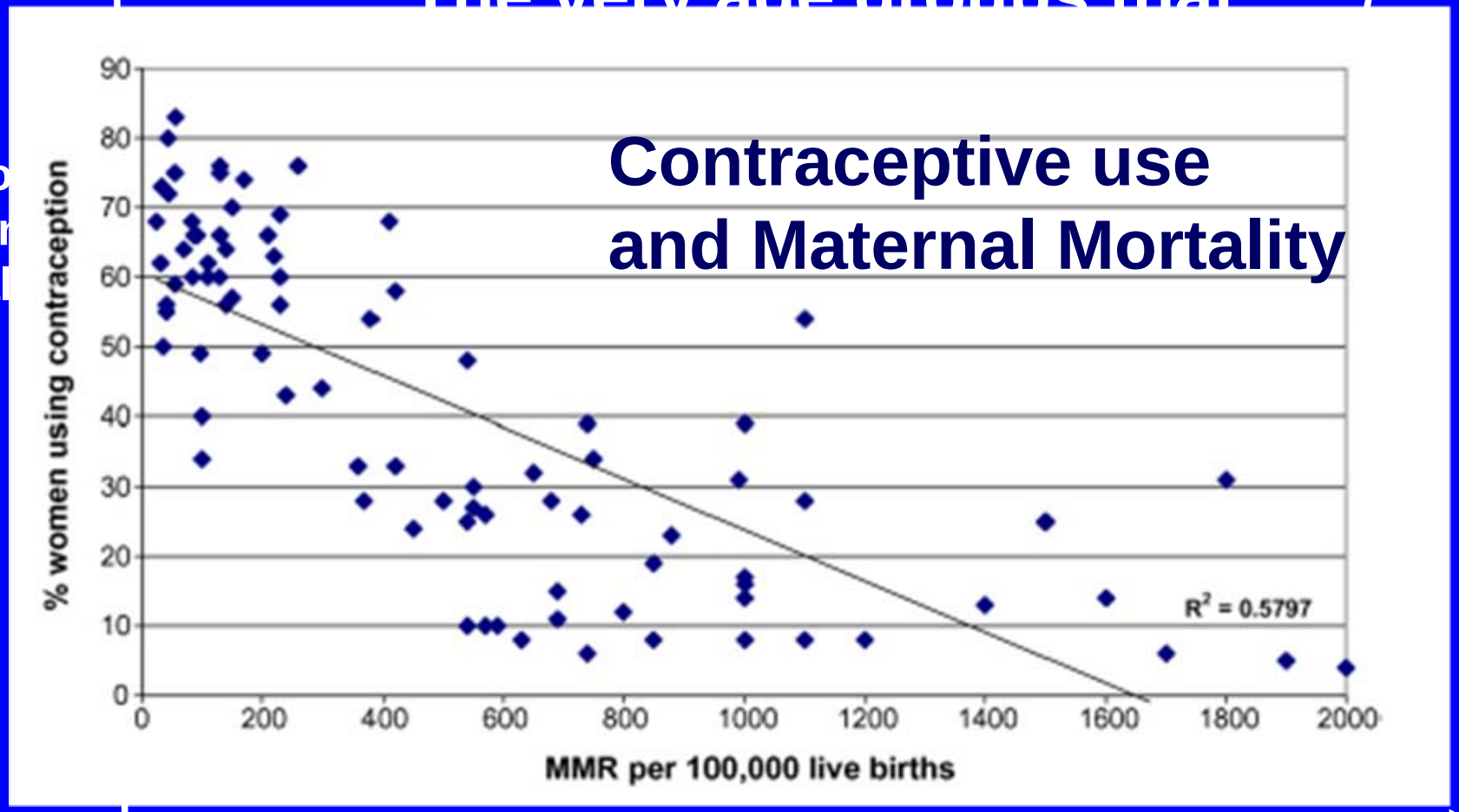

FAO

# Most cost-effective GHG control device is probably a condom

- Many tens of millions of women wish to have fewer children, but do not have access to contraceptives
- Giving them access could mean 1-2 billion fewer people by 2100 – a major reduction of stress on the Earth
- Many health benefits, particularly child and maternal mortality, to smaller, more planned families

The very age groups that

Risk o
Materr
Mortal



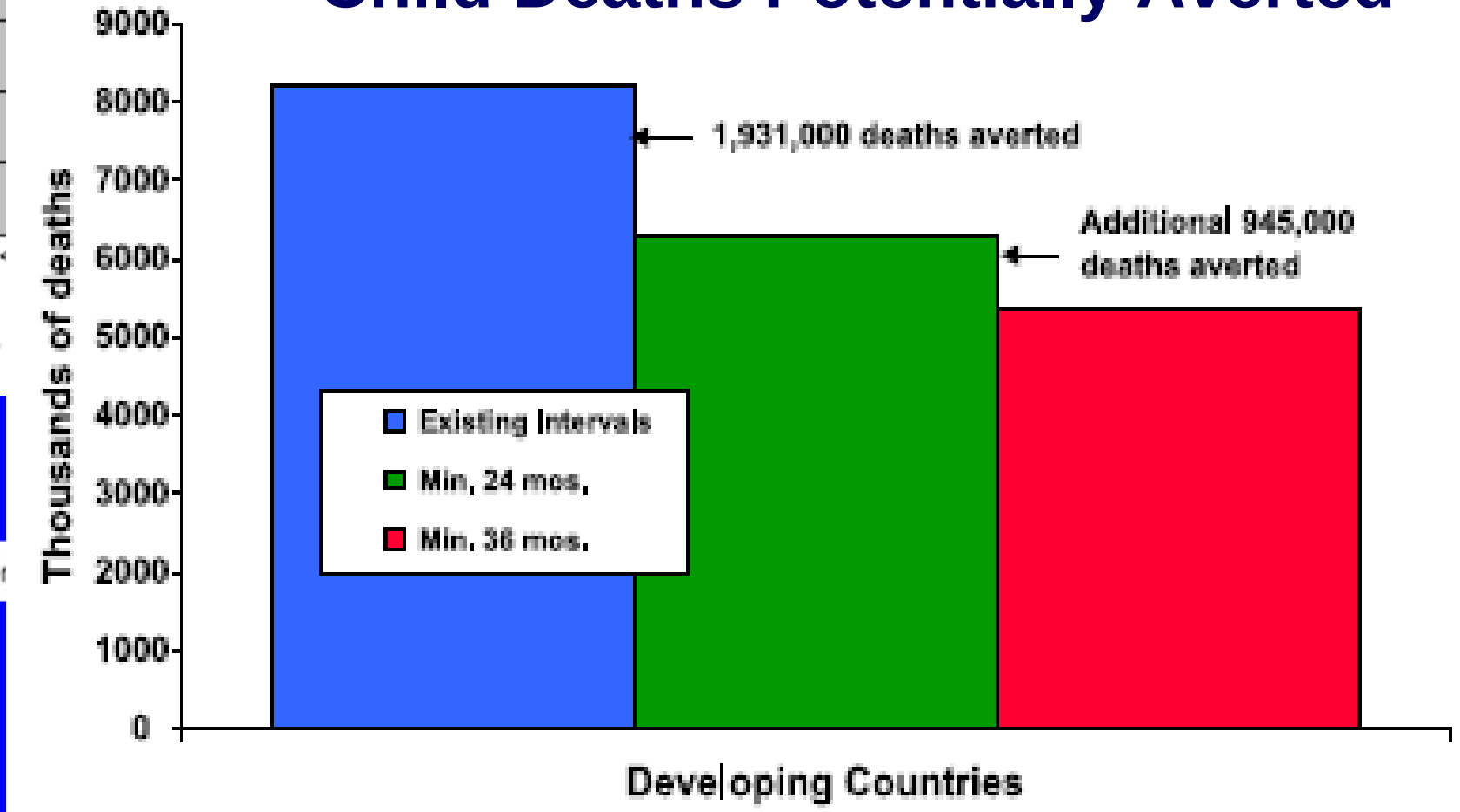

13

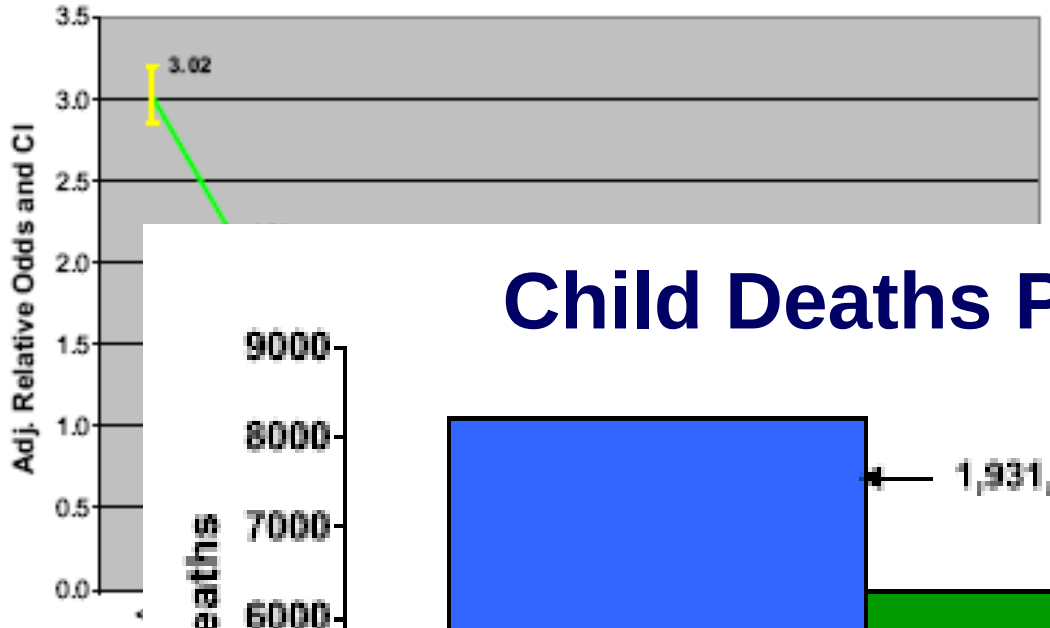
Age of Mother

45

# Child Mortality and Birth

## Child Deaths Potentially Averted

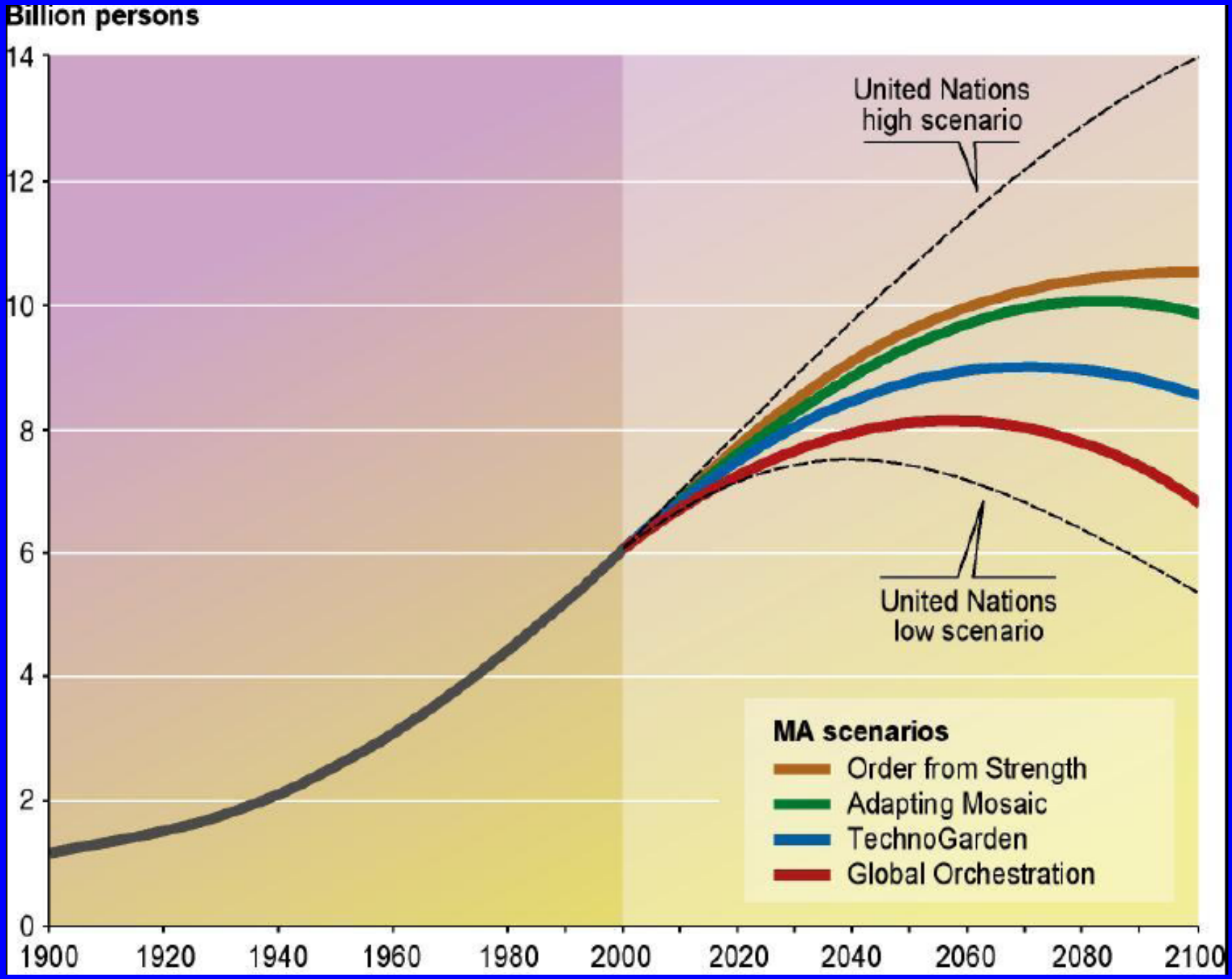



Figure

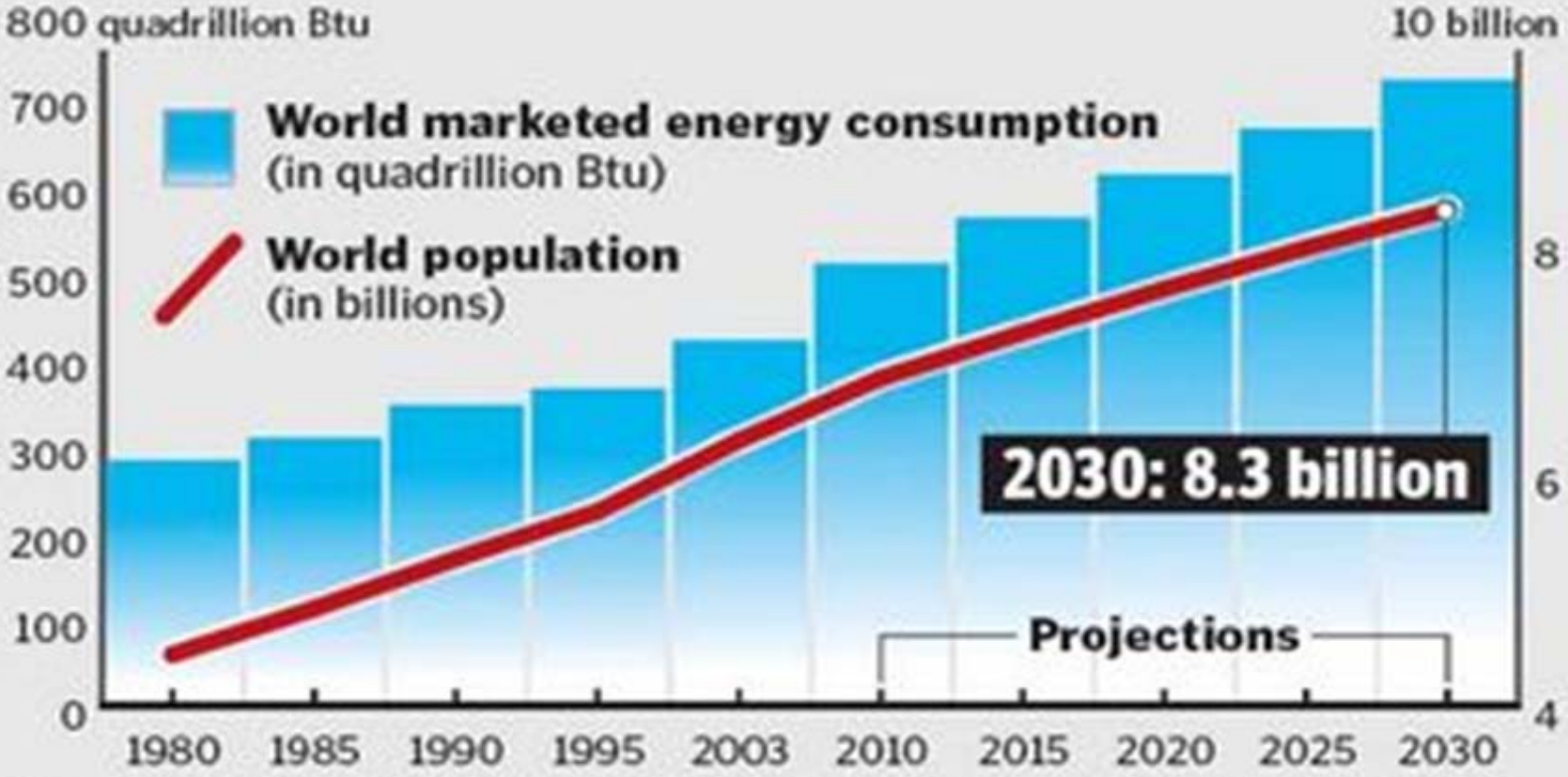



Figure 5 Child malnutrition by birth interval.


Billion persons
14
12
10
8
6
4
2
0
1900
1920
1940
1960
1980
2000
2020
2040
2060
2080
2100
United Nations
high scenario
United Nations
low scenario
MA scenarios
Order from Strength
Adapting Mosaic
TechnoGarden
Global Orchestration

# Energy consumption projected to increase

As the world's population goes up, the demand for energy grows at a similar rate.




Sources: Energy Information Administration; System for the Analysis of Global Energy Markets

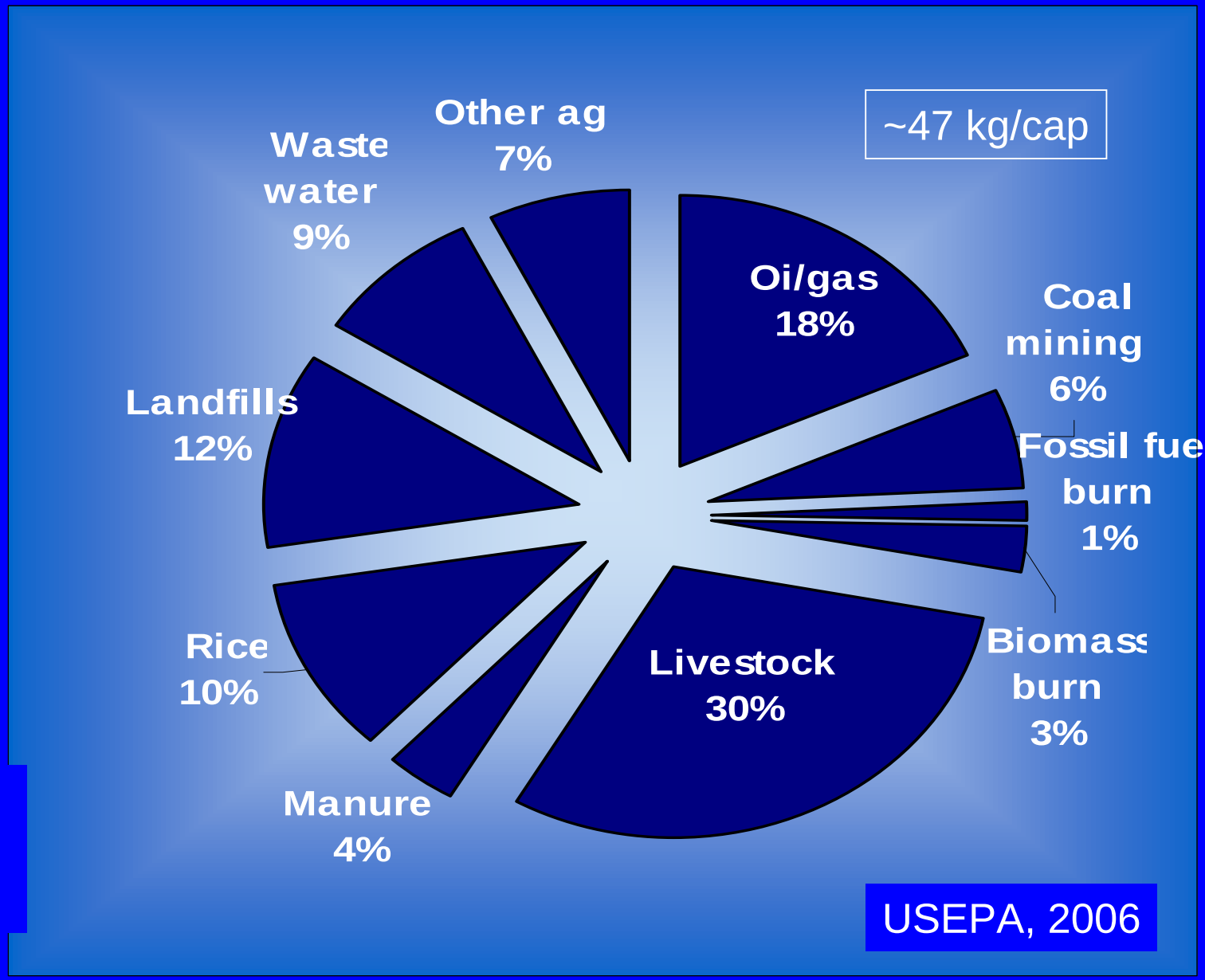
# Access to Reproductive Services

- Not population control, but reproductive rights
- All countries on the way to replacement fertility this century
- Just a matter of making it possible to happen sooner rather than later in the century
- Large health benefits can be accrued

# Methane Reduction

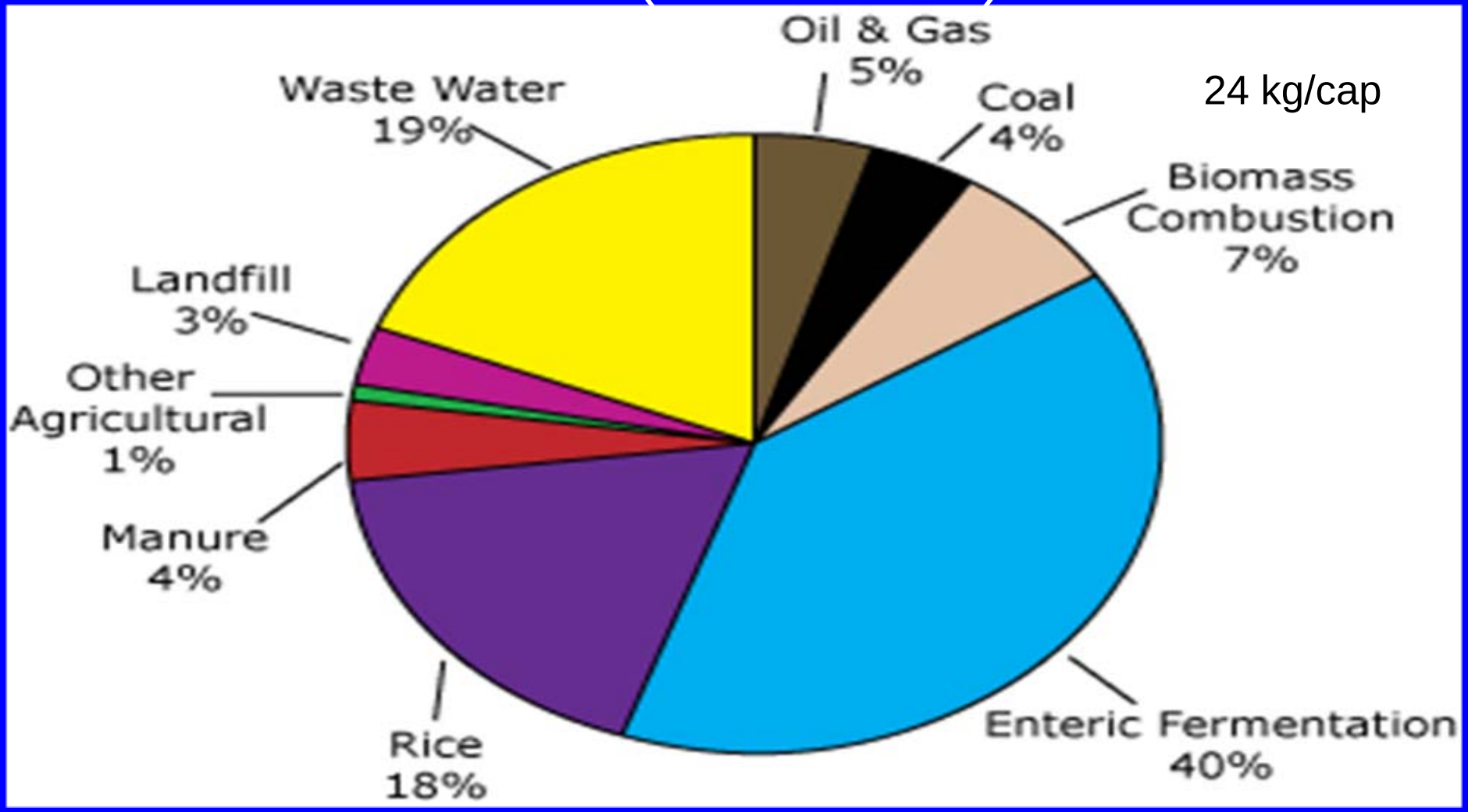
- Major and probably undervalued global GHG
- Major cause of rise in global tropospheric ozone concentrations – important health-damaging and crop-damaging pollutant
- Livestock major source, as noted above
- Leaks: Coal mines, gas pipelines, etc.
- Waste management: Landfills, wastewater
  - Other health benefits here also
- Incomplete combustion: biomass and coal in households

# Global Anthropogenic Methane Emissions ~2005
## Total ~ 305 million tons




Growing at ~1.5% per year

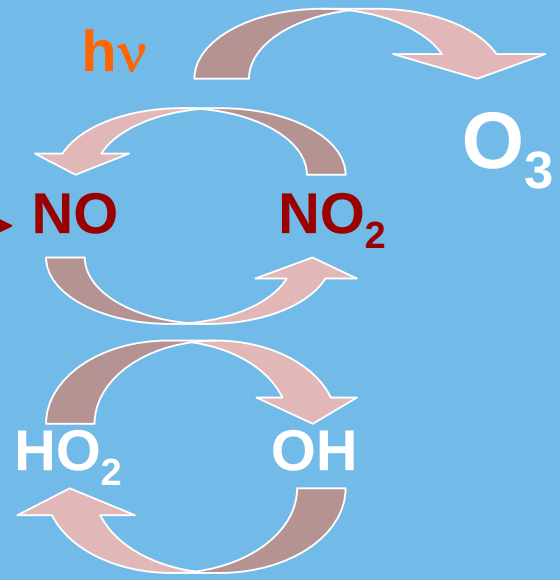
# Methane Emissions from India in 2005
# 26.1 Mt (9% of world)




http://www.epa.gov/nonco2/econ-inv/international.html

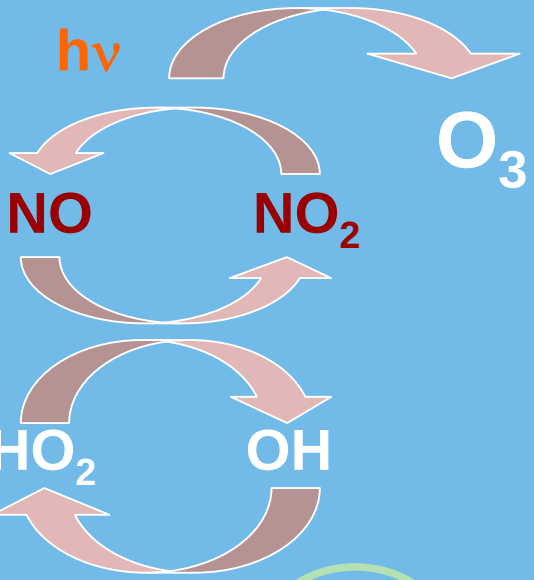
# Methane as a Global Ozone Precursor

## Urban

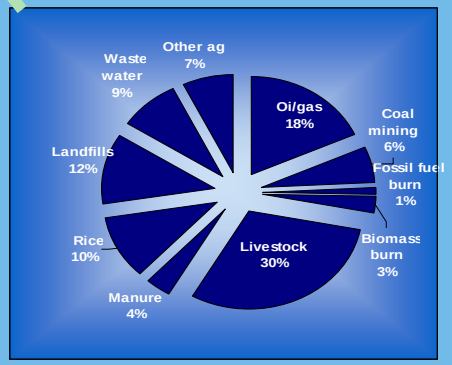



NMVOCs, CO

## Global

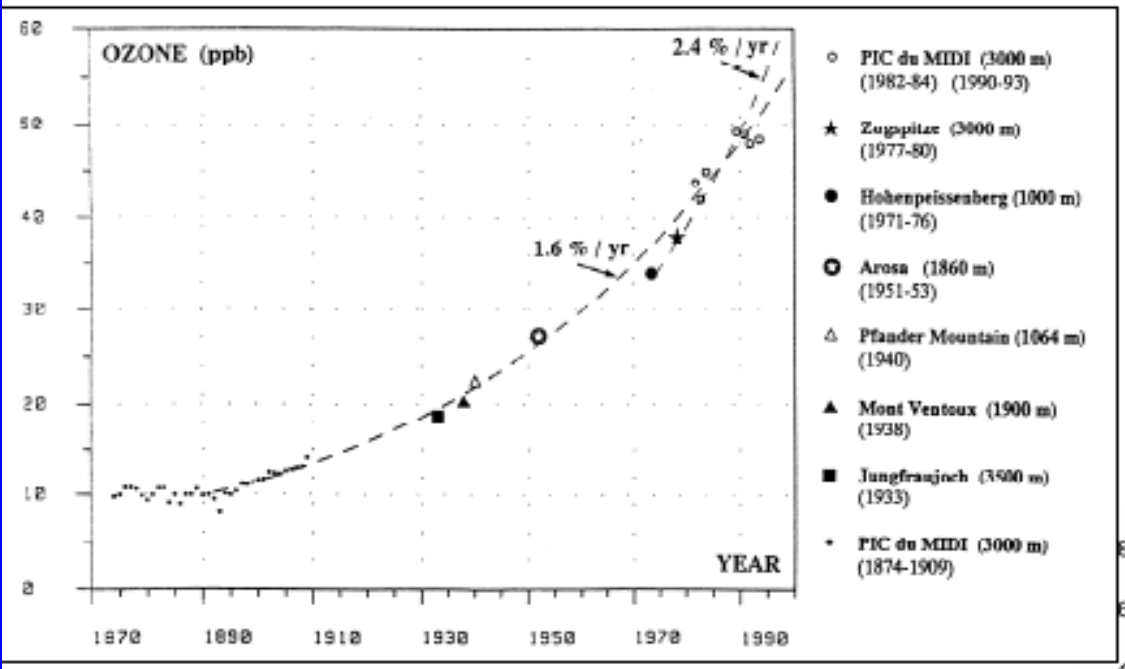



NMVOCs, CO, $CH_4$



# Background Ozone is Growing …

## … and Will Continue to Grow!

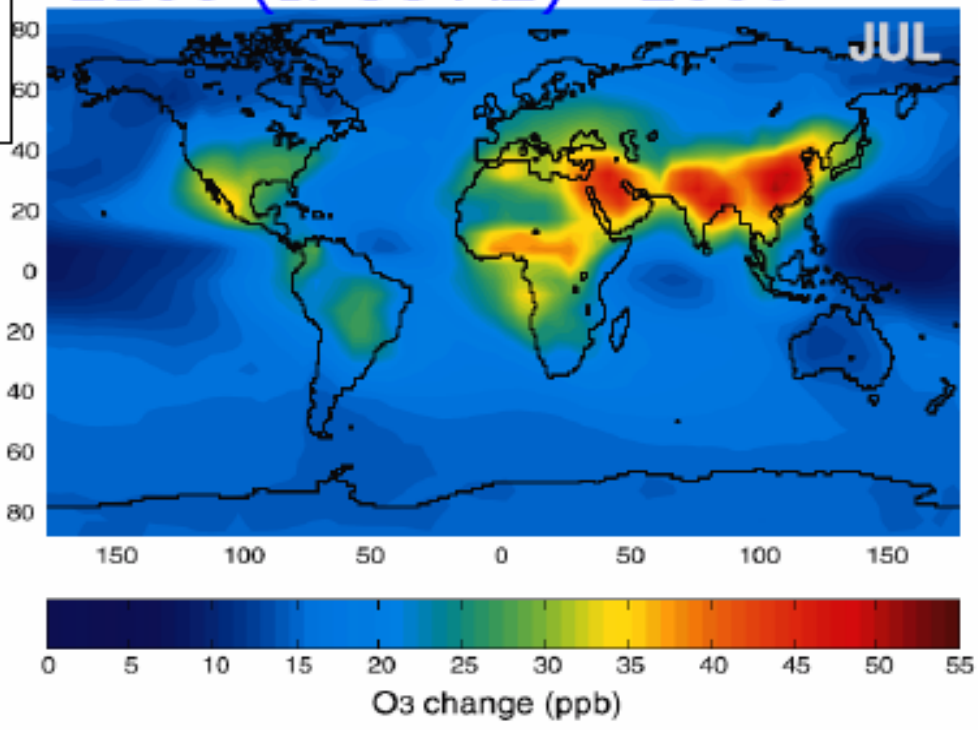



Ozone trend at European mountain sites, 1870-1990 (Marenco et al., 1994).

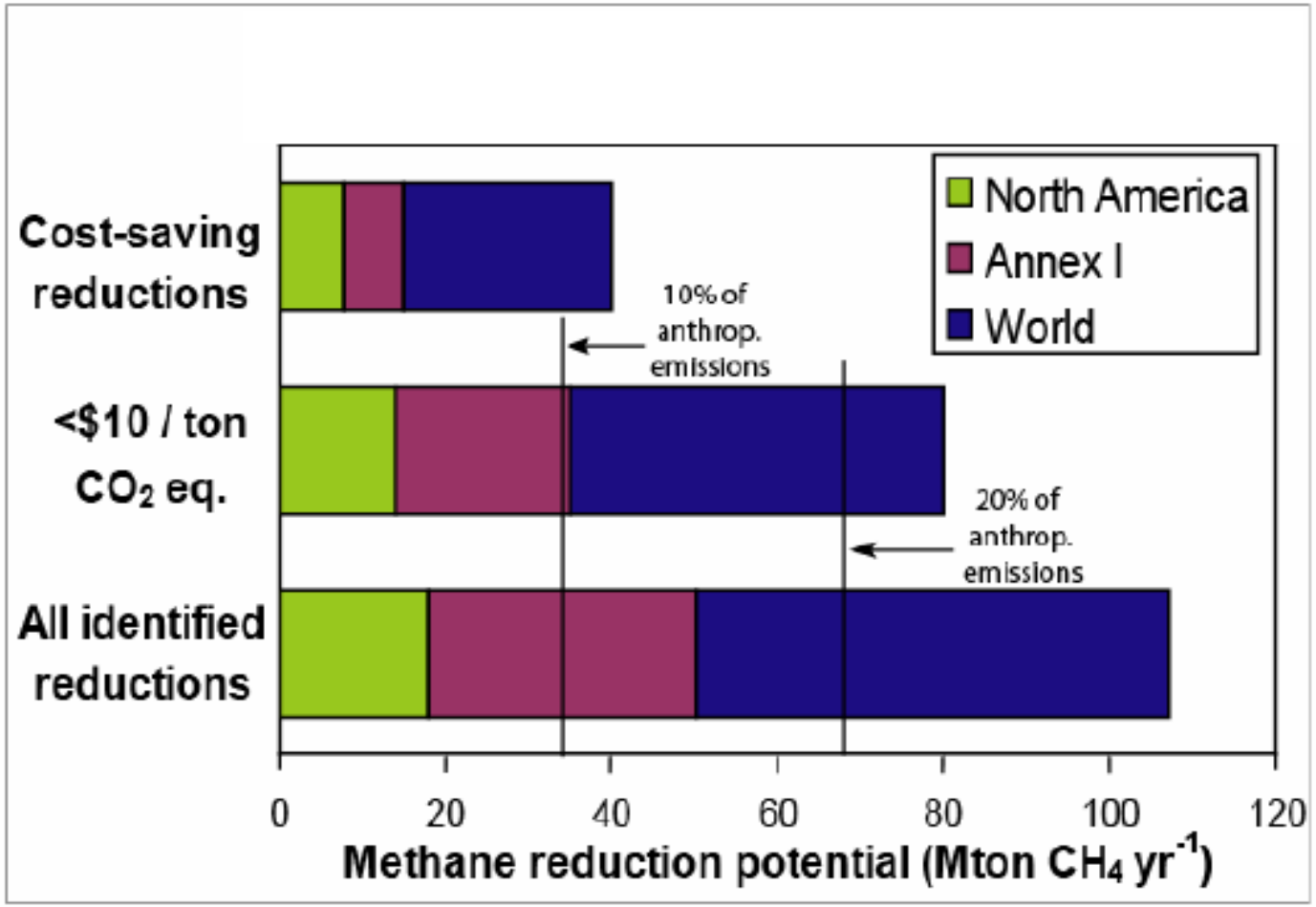
Mauzerall 2007

Historic and future increases in background ozone are due mainly to increased methane and $NO_X$ emissions (Wang *et al.*, 1998; Prather et al., 2003).

2100 (IPCC A2) - 2000



# How Much Can Methane Be Reduced?




West & Fiore (2005)

Methane reduction potential from IEA (2003), for coal, oil and gas operations, wastewater, and landfills; maximum technically feasible in 2010.

# Indian Advanced Cookstove Scenario:

***Estimate the co-benefits of 10-year programme to introduce 150 million low-emission household cookstoves in India***

# Indian Stoves – Traditional and Modern

LOWER CARBON SAVES LIVES

**Per meal**

~15x less black carbon and other particles

~10x less ozone precursors

~5x less carbon monoxide

**Traditional Biomass Stove**

**Gasifier Stove with Electric Blower**
(battery recharged with cell phone charger)

# Cookstove Scenario Assumptions:

- *All health impacts from stoves can be seen immediately*
- *Population size, household size, disability adjusted life years (DALYs) and death rates change linearly*
- *Population receiving stoves uses them consistently & the stoves function well through out the time period*

| | Indian population (millions) | Average number of people per household | Baseline | | | | Stove intervention programme | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Number of households (millions) | Number of households with traditional stoves (millions) | Fraction of traditional stoves | Population using traditional stoves (millions) | Improved stoves distributed (millions) | Number of households with traditional stoves (millions) | Fraction of traditional stoves | Population using traditional stoves (millions) |
| 2010 | 1214* | 4·8 | 252 | 187·1 | 0·74 | 898·1 | 15 | 172·1 | 0·68 | 826·1 |
| 2011 | 1228 | 4·8 | 258 | 187·5 | 0·73 | 890·9 | 15 | 157·5 | 0·61 | 748·3 |
| 2012 | 1242 | 4·7 | 264 | 187·8 | 0·71 | 883·6 | 15 | 142·8 | 0·54 | 671·9 |
| 2013 | 1256 | 4·7 | 270 | 188·1 | 0·70 | 876·3 | 15 | 128·1 | 0·48 | 596·8 |
| 2014 | 1270 | 4·6 | 276 | 188·4 | 0·68 | 868·9 | 15 | 113·4 | 0·41 | 523·1 |
| 2015 | 1285 | 4·6 | 281 | 188·7 | 0·67 | 861·5 | 15 | 98·7 | 0·35 | 450·7 |
| 2016 | 1299 | 4·5 | 287 | 189·0 | 0·66 | 854·0 | 15 | 84·0 | 0·29 | 379·5 |
| 2017 | 1313 | 4·5 | 293 | 189·2 | 0·64 | 846·6 | 15 | 69·2 | 0·24 | 309·7 |
| 2018 | 1327 | 4·4 | 300 | 189·4 | 0·63 | 839·0 | 15 | 54·4 | 0·18 | 241·1 |
| 2019 | 1341 | 4·4 | 306 | 189·6 | 0·62 | 831·5 | 15 | 39·6 | 0·13 | 173·7 |

Percentage of households naturally converting to clean fuels (without stoves) because of economic growth are from reference 9. *Population data from WHO and National Family Health Survey (reference 17).

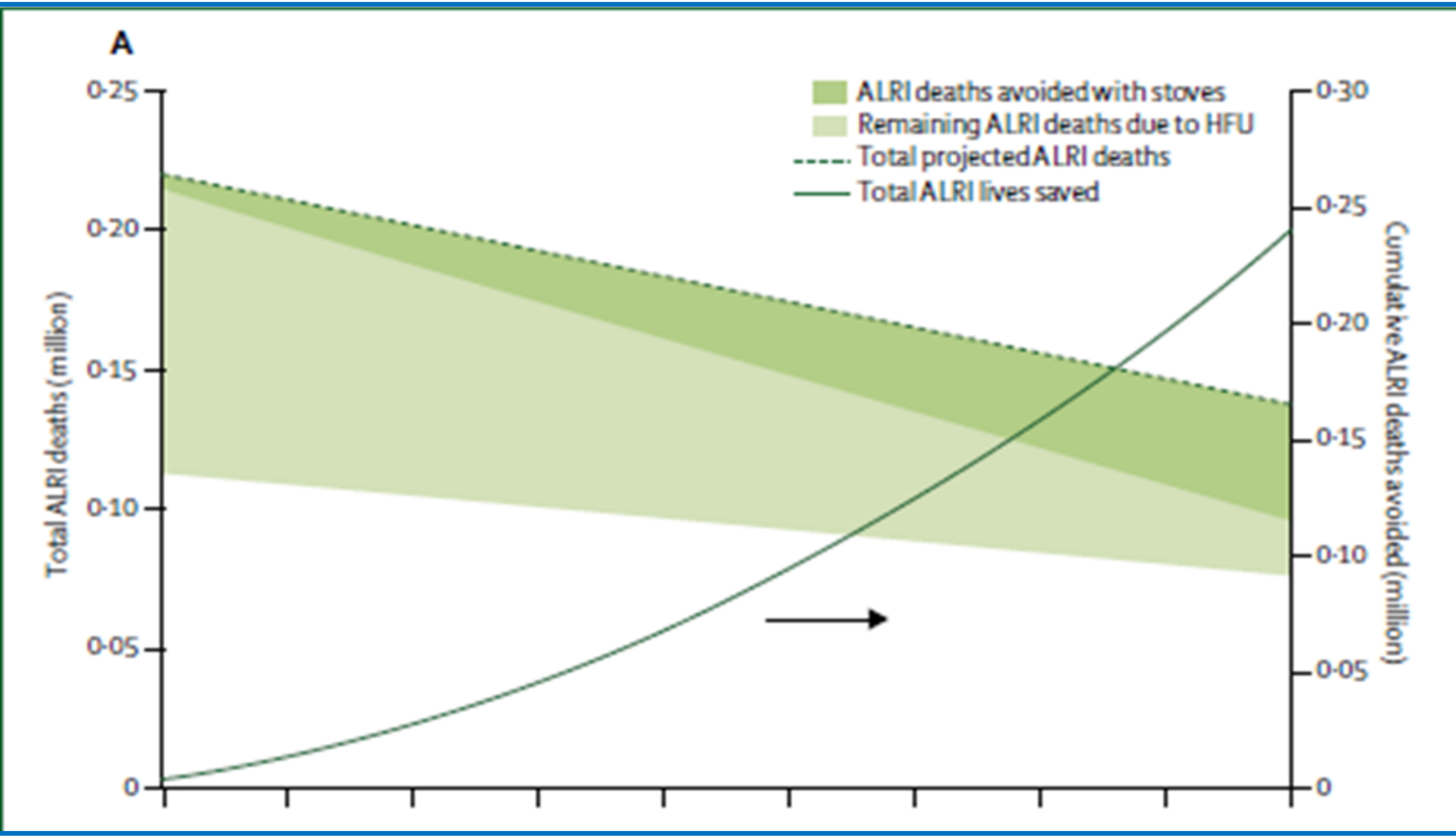
*Table 5:* **Population, number of households, and proportion of households with and without improved stoves at every year of the India cookstove intervention**

# Disease Outcomes Assessed:

- ***Acute Lower Respiratory Infection (ALRI) in children less than 5 years of age***
- ***Chronic Obstructive Pulmonary Disease (COPD) in adults older than 30 years of age***
- ***Ischaemic Heart Disease (IHD) in adults older than 30 years of age***

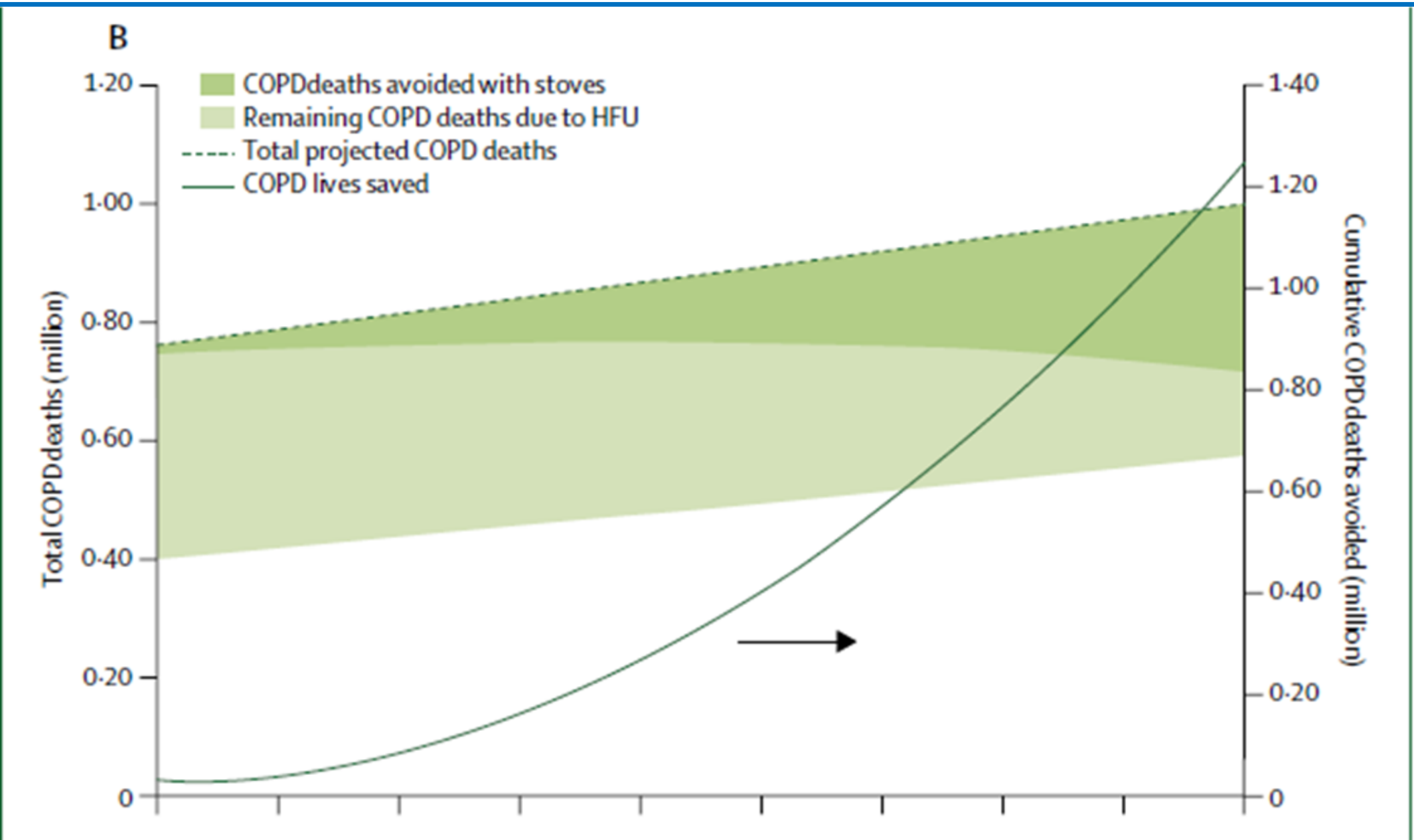
# *ALRI < 5 years*

THE LANCET



# *Chronic Obstructive Pulmonary Disease*

THE LANCET



# *Summary of Disease Burden Avoided*

THE LANCET

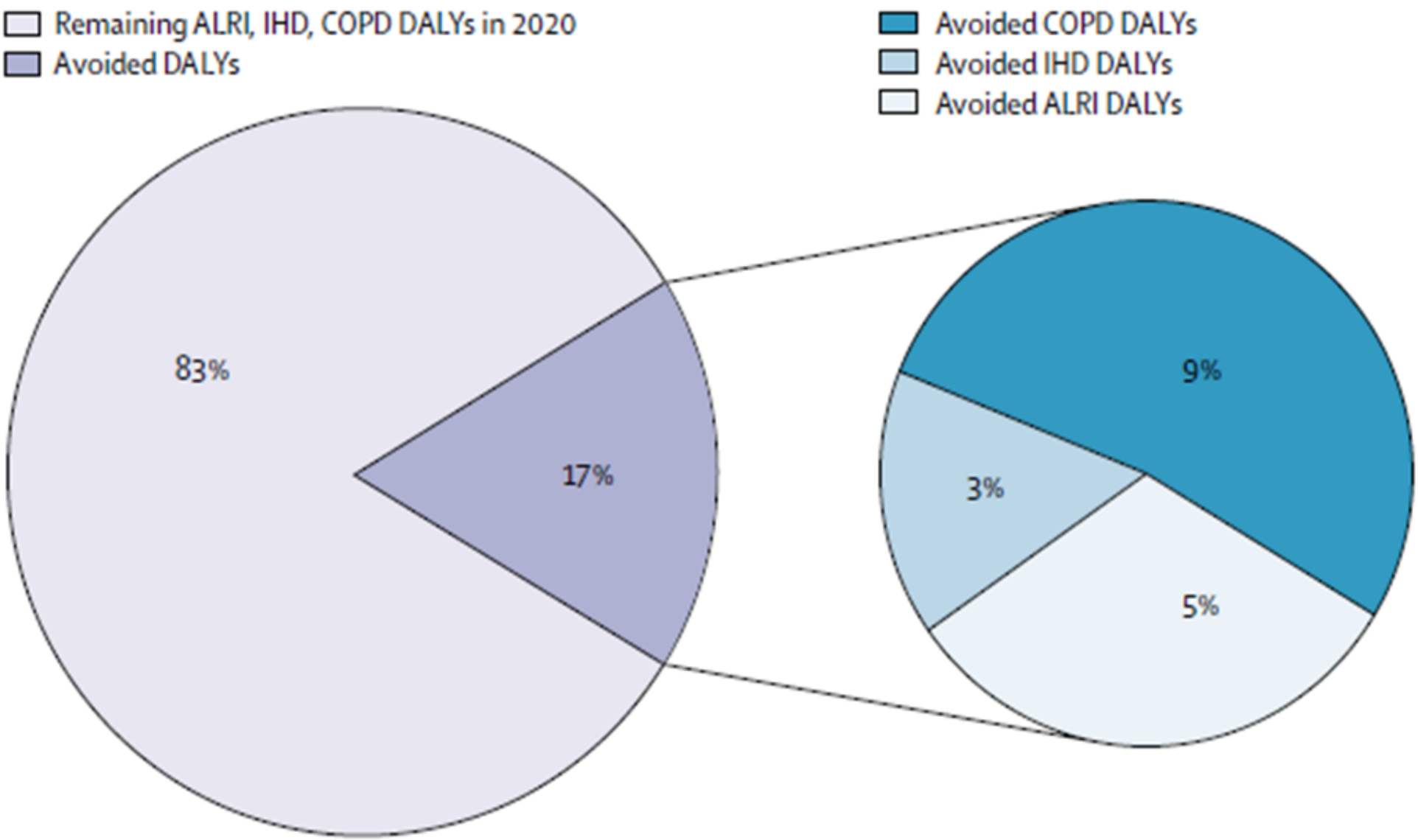
| | Deaths from ALRI | Deaths from COPD | Deaths from IHD | Total DALYs for these diseases |
|---|---|---|---|---|
| Avoided in 2020 (%) | 30·2% | 28·2% | 5·8% | 17·4% |
| Annual number in 2020 without stoves (×10⁶) | 0·14 | 1·00 | 1·77 | 63·0 |
| Total avoided 2010–20 (×10⁶) | 0·24 | 1·27 | 0·56 | 55·5 |

ALRI=acute lower respiratory infections. COPD=chronic obstructive pulmonary disease. IHD=ischaemic heart disease. DALY=disability-adjusted life-year.

*Table* 6: Health benefits of the Indian stove programme

# *Health Benefits Upon Completion, 2020*

THE LANCET

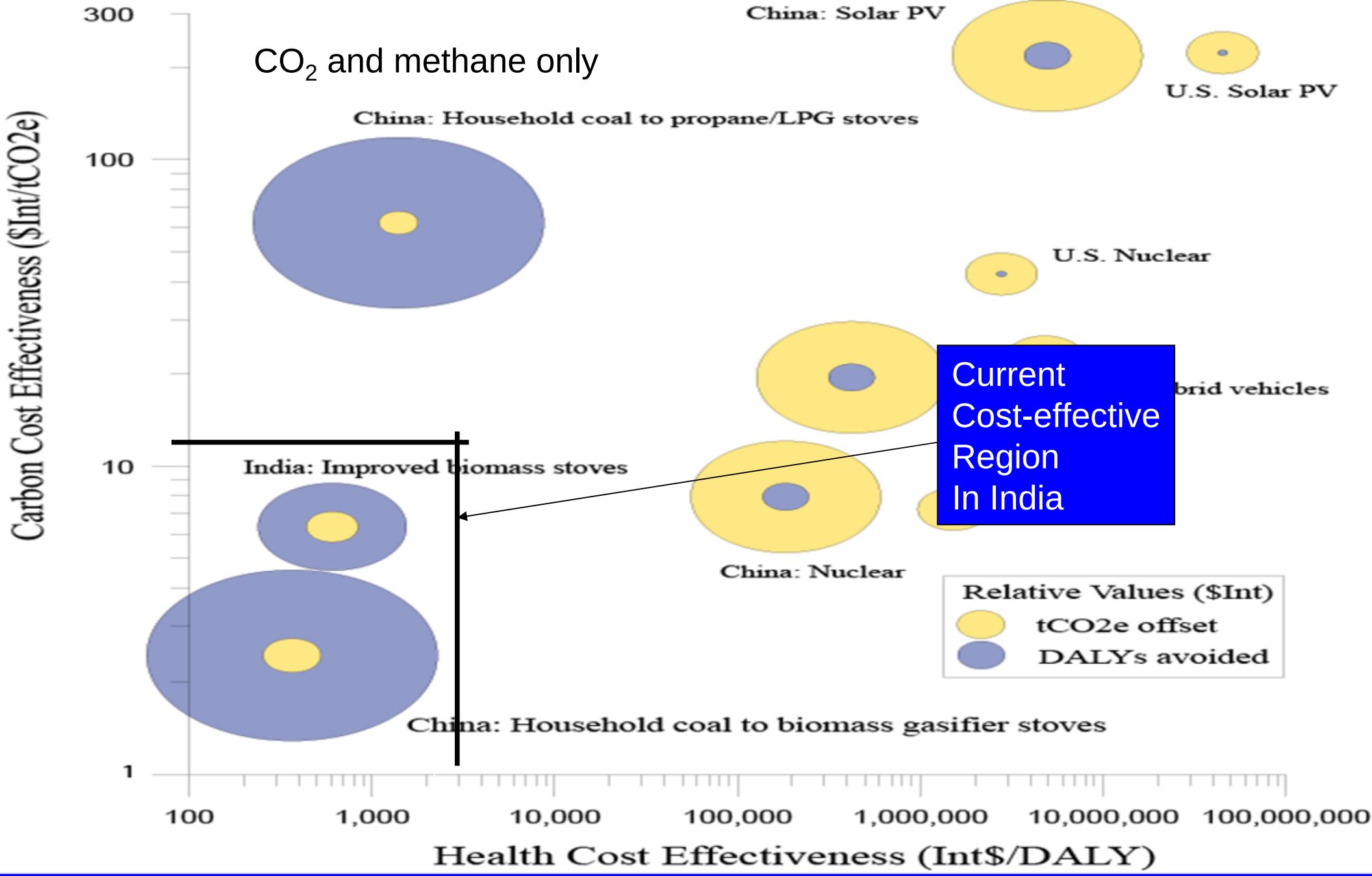


## Key Message:

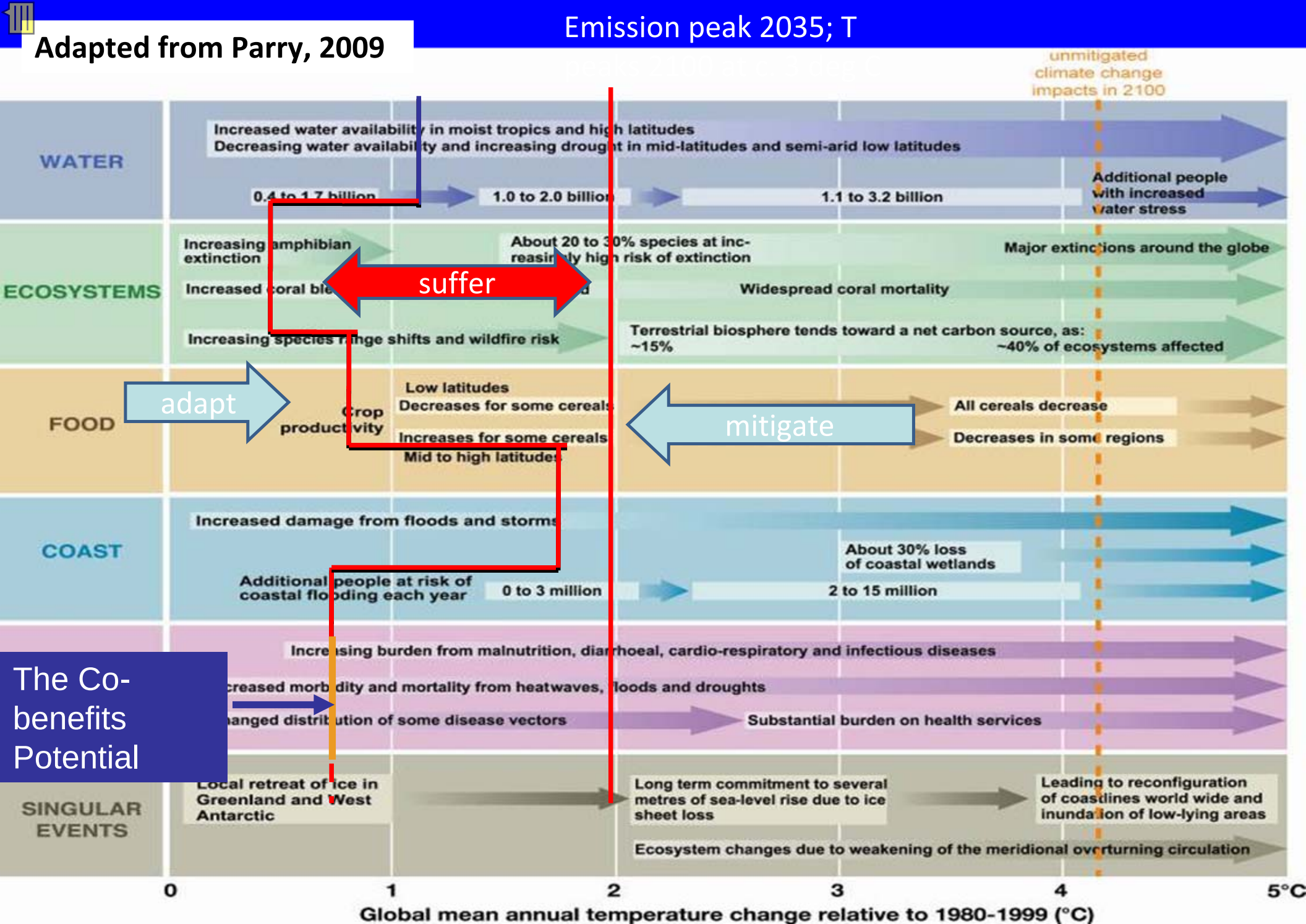
THE LANCET

**Sustained national programs to promote modern low-emissions stove technology for burning of biomass fuels in poor countries provide highly cost—beneficial means to potentially:**

- *Avoid millions of premature deaths*
- *Avoid hundreds of millions of tonnes of $CO_2$-equivalent greenhouse pollutants*
- *Help countries achieve Millennium Development Goals & climate targets*
- *Offer climate-health link with respect to co-benefits*




Smith & Haigler, 2008


Adapted from Parry, 2009
Emission peak 2035; T
unmitigated climate change impacts in 2100
WATER
Increased water availability in moist tropics and high latitudes
Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes
0.4 to 1.7 billion
1.0 to 2.0 billion
1.1 to 3.2 billion
Additional people with increased water stress
ECOSYSTEMS
Increasing amphibian extinction
About 20 to 30% species at increasingly high risk of extinction
Major extinctions around the globe
Increased coral bleaching
Widespread coral mortality
Increasing species range shifts and wildfire risk
Terrestrial biosphere tends toward a net carbon source, as:
~15%
~40% of ecosystems affected
suffer
adapt
mitigate
FOOD
Crop productivity
Low latitudes
Decreases for some cereals
Increases for some cereals
Mid to high latitudes
All cereals decrease
Decreases in some regions
COAST
Increased damage from floods and storms
About 30% loss of coastal wetlands
Additional people at risk of coastal flooding each year
0 to 3 million
2 to 15 million
Increasing burden from malnutrition, diarrhoeal, cardio-respiratory and infectious diseases
Increased morbidity and mortality from heatwaves, floods and droughts
Changed distribution of some disease vectors
Substantial burden on health services
The Co-benefits Potential
SINGULAR EVENTS
Local retreat of ice in Greenland and West Antarctic
Long term commitment to several metres of sea-level rise due to ice sheet loss
Leading to reconfiguration of coastlines world wide and inundation of low-lying areas
Ecosystem changes due to weakening of the meridional overturning circulation
0
1
2
3
4
5°C
Global mean annual temperature change relative to 1980-1999 (°C)

# Thank you

Six papers in *the Lancet Nov 2009*

*Series on Health Benefits of Strategies to Reduce Greenhouse Gases*

- ***Health implications of the short-lived greenhouse pollutants.***
- ***Household energy, UK and India***

**Papers and presentations at my website**

**Google “Kirk R. Smith”**

# Thank you