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

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*Millennium Development Goals

Solar radiation powers the climate system.

Some solar radiation is reflected by the Earth and the atmosphere.

About half the solar radiation is absorbed by the Earth’s surface and warms it.

Infrared radiation is emitted from the Earth’s surface.

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.
There’s no place I’d rather be

Mars
- Thin atmosphere
  (Almost all CO₂ in ground)
- Average temperature: -50°C

Earth
- 0.03% of CO₂ in the atmosphere
- Average temperature: +15°C

Venus
- Thick atmosphere containing 96% of CO₂
- Average temperature: +420°C
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

Anthropogenic Sources

**CO$_2$**
Fossil fuels
Land use change
Cement manufacturing

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

**N$_2$O**
Fertilizer
Planted N-fixers
Combustion

Figure SPM.1
IPCC 2007
1000 years of global C emissions, CO$_2$ concentrations, and temperature
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
<table>
<thead>
<tr>
<th>Confidence Level</th>
<th>Negative Impact</th>
<th>Positive Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very high confidence</strong></td>
<td>Malaria: contraction and expansion, changes in transmission season</td>
<td></td>
</tr>
<tr>
<td><strong>High confidence</strong></td>
<td>Increase in malnutrition</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase in the number of people suffering from deaths, disease and injuries from extreme weather events</td>
<td></td>
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<tr>
<td></td>
<td>Increase in the frequency of cardio-respiratory diseases from changes in air quality</td>
<td></td>
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<tr>
<td></td>
<td>Change in the range of infectious disease vectors</td>
<td></td>
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<tr>
<td></td>
<td>Reduction of cold-related deaths</td>
<td></td>
</tr>
<tr>
<td><strong>Medium confidence</strong></td>
<td>Increase in the burden of diarrhoeal diseases</td>
<td></td>
</tr>
</tbody>
</table>

**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).
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)

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

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**Avoidable Deaths Per Year**

- 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

**Deaths per year if no change in risk** ~200 million dead unnecessarily over 25 years

**“Business as Usual”**

If all goes as predicted, the actual deaths will be ~155 million

**Millennium Development Goals**

**5.1 M/year**

**What more could be done?**

And, indirectly, all these diseases through malnutrition

**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**
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).

Warming in 2005 from emissions since 1750

IPCC, 2007
Where do these PIC come from?

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

Where else?
Population: 6.102 billion
Total energy use: 10.2 Gtoe
Per capita energy consumption: 1.67 toe

Also from solid household fuels Biomass and coal
Total Black Carbon Emissions in 2000

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

- Forest and Grassland: 38.4%
- Household: 24.7%
- Industry: 19.0%
- Transport: 16.6%
- Ships and Aircraft: 1.7%
- Power: 0.7%
- Waste Burning: 0.3%
- Ag Burning: 4.1%

Total: 7900 gigagrams

India ~ One-quarter
More than 75% of households use biomass fuels.

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

50-74% of households used biomass fuels in 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

- Underweight
- Unsafe water/sanitation-E*
- Indoor smoke-E
- Unsafe sex
- Iron deficiency
- Tobacco
- Blood pressure
- Child cluster Vaccination
- Cholesterol
- Road traffic accidents
- Zn Deficiency
- Low fruit & veg
- Occupational (5 kinds)-E
- Lead (Pb)-E
- Climate change-E
- Urban outdoor air-E

Percent of All DALYs in 2000

Disability-adjusted life years

420,000 deaths/year

760,000 deaths/year

KRS from data in World Health Reports – 2001, 02

420,000 deaths/year

760,000 deaths/year
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

<table>
<thead>
<tr>
<th>Place</th>
<th>Year</th>
<th>PM2.5</th>
<th>CH4</th>
<th>CO2</th>
<th>SO2</th>
<th>NOx</th>
<th>N2O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andhra Pradesh</td>
<td>1990</td>
<td>15</td>
<td>4</td>
<td>7</td>
<td>11</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>40</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Tamil Nadu</td>
<td>1990</td>
<td>15</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2005</td>
<td>24</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

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

![Graph showing trends in consumption of livestock products per person](image)

- **Past**:
  - Industrialised countries
  - Transition countries
  - Latin America and the Caribbean
  - East Asia

- **Projected**:
  - Near East/North Africa
  - South Asia
  - Sub-Saharan Africa

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 most wish to avoid pregnancy are those with the highest risk of complications. Contraceptive use and Maternal Mortality.
Child Mortality and Birth

Child Deaths Potentially Averted

Figure 5  Child malnutrition by birth interval.
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

Livestock 30%
Coal mining 6%
Biomass burn 3%
Fossil fuel burn 1%
Manure 4%
Rice 10%
Landfills 12%
Waste water 9%
Other ag 7%
Oi/gas 18%

Growing at ~1.5% per year

~47 kg/cap

USEPA, 2006
Methane Emissions from India in 2005
26.1 Mt (9% of world)

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

24 kg/cap
Methane as a Global Ozone Precursor

Urban

\[ \text{hv} \]

\[ \text{NO} \rightarrow \text{NO}_2 \rightarrow \text{O}_3 \rightarrow \text{HO}_2 \rightarrow \text{OH} \rightarrow \text{NMVOCs, CO} \]

Global

\[ \text{hv} \]

\[ \text{NO} \rightarrow \text{NO}_2 \rightarrow \text{O}_3 \rightarrow \text{HO}_2 \rightarrow \text{OH} \rightarrow \text{NMVOCs, CO, CH}_4 \]

Insert: Source of methane emission:

- Livestock: 4%
- Rice: 10%
- Manure: 4%
- Coal mining: 6%
- Landfill: 12%
- Waste water: 9%
- Other ag: 7%
- Biomas burn: 2%
- Oligas: 16%
- Coal burn: 8%
- Fossil fuel burn: 1%
- Livestock: 30%
Background Ozone is Growing ...

Historic and future increases in background ozone are due mainly to increased methane and NO\textsubscript{X} emissions (Wang et al., 1998; Prather et al., 2003).

2100 (IPCC A2) - 2000

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

Mauzerall 2007
How Much Can Methane Be Reduced?

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

Traditional Biomass Stove

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

Per meal

~15x less black carbon and other particles

~10x less ozone precursors

~5x less carbon monoxide
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 throughout the time period
<table>
<thead>
<tr>
<th>Year</th>
<th>Indian population (millions)</th>
<th>Average number of people per household</th>
<th>Baseline</th>
<th>Stove intervention programme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Number of households (millions)</td>
<td>Number of households with traditional stoves (millions)</td>
</tr>
<tr>
<td>2010</td>
<td>1214*</td>
<td>4.8</td>
<td>252</td>
<td>187.1</td>
</tr>
<tr>
<td>2011</td>
<td>1228</td>
<td>4.8</td>
<td>258</td>
<td>187.5</td>
</tr>
<tr>
<td>2012</td>
<td>1242</td>
<td>4.7</td>
<td>264</td>
<td>187.8</td>
</tr>
<tr>
<td>2013</td>
<td>1256</td>
<td>4.7</td>
<td>270</td>
<td>188.1</td>
</tr>
<tr>
<td>2014</td>
<td>1270</td>
<td>4.6</td>
<td>276</td>
<td>188.4</td>
</tr>
<tr>
<td>2015</td>
<td>1285</td>
<td>4.6</td>
<td>281</td>
<td>188.7</td>
</tr>
<tr>
<td>2016</td>
<td>1299</td>
<td>4.5</td>
<td>287</td>
<td>189.0</td>
</tr>
<tr>
<td>2017</td>
<td>1313</td>
<td>4.5</td>
<td>293</td>
<td>189.2</td>
</tr>
<tr>
<td>2018</td>
<td>1327</td>
<td>4.4</td>
<td>300</td>
<td>189.4</td>
</tr>
<tr>
<td>2019</td>
<td>1341</td>
<td>4.4</td>
<td>306</td>
<td>189.6</td>
</tr>
</tbody>
</table>

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
Chronic Obstructive Pulmonary Disease
### Summary of Disease Burden Avoided

<table>
<thead>
<tr>
<th></th>
<th>Deaths from ALRI</th>
<th>Deaths from COPD</th>
<th>Deaths from IHD</th>
<th>Total DALYs for these diseases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoided in 2020 (%)</td>
<td>30.2%</td>
<td>28.2%</td>
<td>5.8%</td>
<td>17.4%</td>
</tr>
<tr>
<td>Annual number in 2020 without stoves (×10⁶)</td>
<td>0.14</td>
<td>1.00</td>
<td>1.77</td>
<td>63.0</td>
</tr>
<tr>
<td>Total avoided 2010–20 (×10⁶)</td>
<td>0.24</td>
<td>1.27</td>
<td>0.56</td>
<td>55.5</td>
</tr>
</tbody>
</table>

**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

Remaining ALRI, IHD, COPD DALYs in 2020
Avoided DALYs

- 83%
- 17%

Avoided COPD DALYs
Avoided IHD DALYs
Avoided ALRI DALYs

- 9%
- 3%
- 5%
Key Message:

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 CO₂-equivalent greenhouse pollutants
• Help countries achieve Millennium Development Goals & climate targets
• Offer climate-health link with respect to co-benefits
CO₂ and methane only

Current Cost-effective Region In India

Smith & Haigler, 2008
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