The implications of a changing climate on global nutrition security

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“The warming of the climate is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.”

-- Fifth Assessment Report (AR5) of the IPCC, 2013
ANTHROPOGENIC CO₂ EMISSIONS AND GLOBAL TEMPERATURE ANOMALIES (1890-2100)

Source: IPCC, 2013
MASS BALANCE OF ANTARCTIC AND GREENLAND ICE SHEETS, 1992-2010

OCEAN SURFACE ACIDITY (1900-2100) UNDER DIFFERENT CLIMATE CHANGE SCENARIOS

Source: World Bank, Turn Down the Heat, 2013
“Climate change is the biggest global health threat of the 21st century.”

-- *Lancet*-University College London Commission, 2009
OBJECTIVES

• Identify the principal conceptual linkages between the biophysical manifestations of climate change and nutrition security

• Elaborate mitigation and adaptation options for addressing the threat of climate change to nutrition security
Agricultural production & food security
## Domains of Food Security

<table>
<thead>
<tr>
<th>Availability</th>
<th>Access</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physically available</td>
<td>Physically accessible</td>
<td>Allocated to individuals</td>
</tr>
<tr>
<td></td>
<td>Economically accessible</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safe to consume</td>
<td>Consumed by individual</td>
</tr>
<tr>
<td></td>
<td>Culturally acceptable</td>
<td>Individual nutritional status</td>
</tr>
<tr>
<td></td>
<td>Acquired by HH</td>
<td></td>
</tr>
</tbody>
</table>

Source: Jones et al, What Are We Assessing When We Measure Food Security?, 2013
GROWING SEASON TEMPERATURE TRENDS SINCE 1980, BY CROP REGION

ESTIMATED SOWING DATES FOR SPRING OATS AND MAIZE IN NORTHERN AND CENTRAL EUROPE

- Warmer temperatures alter the rate of plant development by reducing critical growth periods

- Accelerated crop ripening and shorter periods for grain filling can decrease yields

Source: Olesen et al., 2012
PROJECTED % CHANGE IN CROP YIELDS (2010-2050)

LIVESTOCK & RISING SURFACE TEMPERATURES

- Livestock reduce feed intake at high temperatures to maintain body temperature which may result in productivity losses.

- Increases in pasture productivity expected in highland areas, though reduced water availability expected to negatively affect pasture biomass production.

- Warmer temperatures may facilitate spread of animal diseases and pests.

Source: http://www.hardrainproject.com
ARIDITY & CROP PRODUCTION

- Warming of the lower atmosphere will likely cause dry regions to become drier and wet regions to become wetter.

- More intense droughts through increased evaporation and evapotranspiration that accompanies warming temperatures.

- Soil N and organic C concentrations may decline under arid conditions, becoming uncoupled from soil phosphorus P; could constrain plant and microbial activity and negatively affect organic matter decomposition.

- Soil moisture deficits can decrease nutrient acquisition, reduce biological nitrogen fixation, and disrupt nutrient cycling.
**PRECIPITATION & CROP PRODUCTION**

- Extreme precipitation over mid-latitude land masses and wet tropical regions will intensify and become more frequent.

- Increases in annual runoff may be unevenly distributed across seasons.

- Excessive precipitation can reduce crop yields, erode sloped soils, contribute to soil nutrient loss, create conditions of hypoxia that promote elemental toxicities, impair root growth, and reduce nutrient uptake.

- Volatility in the onset and ending of rains may disrupt germination and require farmers to sow crops multiple times.

Source: http://www.worldpolicy.org
GLOBAL PREVALENCE OF <5 CHILD STUNTING

Source: de Onis et al, PHN 2011
ESTIMATED CHANGES IN GLOBAL CEREAL PRICES UNDER SEVEN CLIMATE SCENARIOS

Source: Parry et al. Global Environmental Change, 2004
PREVALENCE OF OVERWEIGHT AND OBESE <5 CHILDREN, 1990-2020

Source: de Onis et al, American Journal of Clinical Nutrition, 2010
The stability of natural ecosystems, human livelihoods and regional security
ECOSYSTEM FUNCTIONING AND CLIMATE CHANGE

• Ecosystem functioning and service provision are expected to change under warming global temperatures, for example:

  – widespread forest retreat and transition to lower biomass, drier ecosystems

  – more frequent and intense forest fires from heat stress, increasing aridity, and changes in human land use

  – expansion of ocean hypoxic zones and declines in nutrient availability to phytoplankton under warming ocean temperatures

  – erosion or destruction of coral reefs from ocean acidification, and increased frequency and intensity of tropical cyclones

  – loss of mangroves from rising sea levels and increasing atmospheric CO₂ concentrations

Source: World Bank, Turn Down the Heat, 2013
Global mean temperature increases greater than 2°C will put at risk of extinction 20 to 30 percent of plant and animal species.

-- Intergovernmental Panel on Climate Change, 2007
Disease vectors and human nutrition
MEAN AMBIENT TEMPERATURE AND CHILDREN <10 Y ADMITTED TO HOSPITAL FOR DIARRHEA, LIMA, PERU (1993-1998)

DIARRHEAL ILLNESS AND AMBIENT TEMPERATURE

• Reliance on stagnated or otherwise contaminated secondary water sources during droughts

• Increases in the population density or activity of flies that carry diarrheal-disease causing organisms during periods of high temperatures

• Higher temperatures increase exposure to bacterial and parasitic diarrhea, lengthen survival of bacteria such as enterotoxigenic *E. coli* in contaminated food

• Increased runoff could transfer pathogens from environmental reservoirs to ground and surface water, and increase incidence of diarrhea
VECTOR-BORNE ILLNESS

• Warming temperatures are allowing mosquito populations to expand into highland regions where they previously were never observed (by 2050 more than 200 million additional individuals may be at risk for malaria)

• Stagnant water from extreme rain events and flooding under climate change may provide additional habitat for mosquitoes

• Climate change will likely also influence the distribution and survival of other disease vectors including those that cause leishmaniasis, Lyme disease and schistosomiasis

Source: http://uaidintl.org
MALNUTRITION

Decreased quality and quantity of crop and livestock production

CLIMATE

Warmer temperatures, extreme seasonal heat, & increasing aridity

Increased exposure to vector-borne disease, diarrheal and respiratory illnesses

Increased susceptibility to pests and disease

Increased access to food and/or food of adequate quality

Changes in crop phenology

Loss of livelihood, increased time and labor burdens

Decreased soil moisture

Ecosystem disruption

Decreased caring capacity

Heavy precipitation events

Loss of biodiversity

Conflict, displacement

Water contamination

Degradation of soil nutrient uptake and availability

Flooding

Decreased soil nutrient uptake and availability

Loss of livelihood, increased time and labor burdens

Decreased carrying capacity

Decreased soil moisture

Ecosystem disruption

Decreased access to food and/or food of adequate quality

Decreased quality and quantity of crop and livestock production

Decreased pasture biomass

Enhanced evapotranspiration

Changes in crop phenology

Reduction of livestock feed intake

Decreased quality and quantity of crop and livestock production

Distribution and survival of disease vectors

Flooding

Increased exposure to vector-borne disease, diarrheal and respiratory illnesses
Source: Costello et al, Managing the health effects of climate change, The Lancet, 2009
Deforestation and land clearing for agriculture, as well as other agriculture-related emissions (e.g. management of soils, livestock, rice production and biomass burning) together contribute nearly a third of all GHG emissions (31%).
CLIMATE CHANGE MITIGATION THROUGH THE AGRICULTURE SECTOR

• Reducing food waste

• Limiting livestock production and reducing the ecological footprint of animal agriculture

• Removing subsidies that promote overexploitation of natural resources and securing property rights for commons and waste sinks

• Payment for ecosystem services (PES)

• Adopting practices based on principles of agroecological intensification:
  – selecting well-adapted, hybrid or high-yielding seeds,
  – planting and harvesting at suitable times
  – employing integrated pest management
  – increasing the efficiency of fertilizer and water use
  – applying integrated soil and nutrient management
  – leveraging agro-forestry and recycling of agricultural by-products
Nutrition-specific interventions

DIET & HEALTH STATUS

- Household food security
- Healthy homes & access to health services
- Care for women and children
Nutrition-specific interventions

Nutrition-sensitive interventions

Climate change resilience interventions

Household food security

Healthy homes & access to health services

Care for women and children

Sustainable access to productive resources

DIET & HEALTH STATUS
THANK YOU

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• Adopting cropping systems with reduced reliance on inorganic fertilizers and pesticides (e.g. using legumes in crop rotations and providing temporary vegetative cover between successive crops)

• improving nitrogen (N) use efficiency to reduce N₂O emissions

• adopting reduced- or no-till agriculture to reduce soil carbon losses

• increasing the use, efficiency and effectiveness of irrigation to enhance carbon storage in soils (though CO₂ costs associated with water delivery would need to be minimized)

• using agro-forestry to increase soil carbon sequestration by planting trees on the same land used for food and livestock production
Interventions in women of reproductive age and during pregnancy

- folic acid supp.
- Fe or IFA supp.
- MMN supp.
- Ca supp.
- I supp.

Nutritional interventions in infants and children

- vitamin A supp.
- Fe supp.
- Zn supp.
- MMN supp.
- CF promotion
- BF promotion

Nutritional interventions in neonates

- vitamin K admin.
- vitamin A supp.
- delayed cord clamping
- MMN supp.
- MMN supp.
- MMN supp.
- MMN supp.

Disease prevention & management

- WASH
- maternal deworming
- IPTp/ITN for malaria in pregnancy
- malaria prophylaxis in children
- deworming in children
- Zn therapy for diarrhea
- kangaroo mother care
Interventions in women of reproductive age and during pregnancy:
- Energy + protein supp.
- Folic acid supp.
- Fe or IFA supp.
- Ca supp.
- MMN supp.
- I supp.

Nutritional interventions in infants and children:
- Vitamin A supp.
- Fe supp.
- Zn supp.
- MMN supp.
- CF promotion
- BF promotion

Nutritional interventions in neonates:
- Vitamin K admin.
- Delayed cord clamping
- Vitamin A supp.
- Kangaroo mother care

Disease prevention & management:
- WASH
- Maternal deworming
- Malaria prophylaxis in children
- Malaria therapy for diarrhea
- IPTp/ITN for malaria in pregnancy
- Deworming in children

Source: Bhutta et al. *Lancet* 2013
“livestock’s long shadow”

• Animal agriculture releases 18% of greenhouse gases world-wide (> all cars, trucks, planes, and ships in the world combined)

• The world’s cattle alone consume a quantity of food equal to the caloric needs of 8.7 billion people

• Raising animals for food (including land used for grazing and land used to grow feed crops) uses 30% of the Earth’s land mass

• To produce a day’s food for one meat-eater takes over 4,000 gallons of water; for a lacto-ovo vegetarian, 1200 gallons; for a vegan, 300 gallons

• The production of one calorie of animal protein requires more than ten times the fossil fuel input as a calorie of plant protein
GROWING SEASON TEMPERATURE TREND (1980-2008)

Source: Lobell DB. Climate Trends and Global Crop Production Since 1980. Science 2011
CLIMATE CHANGE & NUTRITION PATHWAYS

1. Agricultural production and food security

2. The stability of natural ecosystems, human livelihoods and regional security

3. the distribution and survival of Disease vectors and human health and nutrition
OUTLINE

• Words about how I know Per and tribute to him
• Why I chose to write about climate change; how it intersects with Per’s research and the topics in the Festschrift
• Typhoon, other events in news media
• Newest CC report from IPCC; CO2 graph, temperature data, Artic sea ice, ocean acidification
• RCPs
• Climate change consequences and their pathways of impact on human nutrition

• Agricultural production and food security
• The stability of natural ecosystems, human livelihoods and regional security
• Disease vectors and human health and nutrition
• Strategies for reducing the potential harmful impacts of climate change on nutrition
• Mitigation
• Adaptation
Specific projections vary with
the climate model scenario used, the simulations
methods, and the time scale over which the projections
are done. However, the broad-scale pattern
of climate change impacts on crop productivity
and production has remained consistent across
all of these global studies spanning almost
20 years of research. Crop yields are more negatively
affected across most tropical areas than at
higher latitudes, and impacts become more severe
with an increasing degree of climate change.
Furthermore, large parts of the world where crop
productivity is expected to decline under climate
change (Fig. 2) coincide with countries that currently
have a high burden of hunger (Fig. 1).

We
conclude that there is a robust and coherent pattern
on a global scale of the impacts of climate change
on crop productivity and, hence, on food availability
and that climate change will exacerbate food
insecurity in areas that already currently have a
high prevalence of hunger and undernutrition.
ESTIMATED EFFECTS OF CLIMATE CHANGE ON DALYs (2000)

<table>
<thead>
<tr>
<th>Region</th>
<th>Total DALYs (1000s)</th>
<th>DALYs per million population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa region</td>
<td>1894</td>
<td>3071.5</td>
</tr>
<tr>
<td>Eastern Mediterranean region</td>
<td>768</td>
<td>1586.5</td>
</tr>
<tr>
<td>South America and Caribbean region</td>
<td>92</td>
<td>188.5</td>
</tr>
<tr>
<td>Southeast Asia region</td>
<td>2572</td>
<td>1703.5</td>
</tr>
<tr>
<td>Western Pacific region*</td>
<td>169</td>
<td>111.4</td>
</tr>
<tr>
<td>Developed countries†</td>
<td>8</td>
<td>8.9</td>
</tr>
<tr>
<td>World</td>
<td>5517</td>
<td>920.3</td>
</tr>
</tbody>
</table>

*Without developed countries. †And Cuba.

Source: Costello et al, Managing the health effects of climate change, The Lancet, 2009
The far-reaching influence of climate change on Earth’s underlying biological and physical systems has the potential to directly or indirectly affect access to all of these resources, and therefore, the health and nutrition of the global population.
PREVALENCE OF OVERWEIGHT AND OBESE <5 CHILDREN, 1990-2020

Source: de Onis et al, 2010
• Black 2013, underlying conditions not addressed
• Climate change will affect those
• Dentist’s office: 2-3C
Potential resources

Economic structure

Political & ideological superstructure

Resource & control (Human, economical & organizational)

Information, education, communication

Care for children and women

Health services & healthy environment

Household food security

Dietary intake ➜ Health status

Survival, growth & development

Immediate causes

Underlying causes

Basic causes

Source: UNICEF, 1990
• What has been done on this to date
• More on food security than nutrition explicitly
PER PERSON CO2 EMISSIONS IN HIGH- AND LOW-INCOME COUNTRIES

Food production systems (i.e. diversity of production, market-orientation of production, labor supply and demand, management practices) may influence maternal and child nutrition through:

- household dietary intake
- household income
- energy expenditure
- time use and caregiving capacity
- direct health risks
- control of productive resources
- food safety
- long-term livelihood & food security
• PER SLIDE
• ECOLOGICAL PICTURE – INTERSECTIONS WITH NUTRITION (ECONUTRITION PERSPECTIVE)
<table>
<thead>
<tr>
<th>Scenario</th>
<th>2046–2065</th>
<th></th>
<th>2081–2100</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Likely range</td>
<td>Mean</td>
<td>Likely range</td>
</tr>
<tr>
<td>RCP2.6</td>
<td>1.0</td>
<td>0.4 to 1.6</td>
<td>1.0</td>
<td>0.3 to 1.7</td>
</tr>
<tr>
<td>RCP4.5</td>
<td>1.4</td>
<td>0.9 to 2.0</td>
<td>1.8</td>
<td>1.1 to 2.6</td>
</tr>
<tr>
<td>RCP6.0</td>
<td>1.3</td>
<td>0.8 to 1.8</td>
<td>2.2</td>
<td>1.4 to 3.1</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>2.0</td>
<td>1.4 to 2.6</td>
<td>3.7</td>
<td>2.6 to 4.8</td>
</tr>
<tr>
<td><strong>Global Mean Surface Temperature Change (°C)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RCP2.6</td>
<td>0.24</td>
<td>0.17 to 0.32</td>
<td>0.40</td>
<td>0.26 to 0.55</td>
</tr>
<tr>
<td>RCP4.5</td>
<td>0.26</td>
<td>0.19 to 0.33</td>
<td>0.47</td>
<td>0.32 to 0.63</td>
</tr>
<tr>
<td>RCP6.0</td>
<td>0.25</td>
<td>0.18 to 0.32</td>
<td>0.48</td>
<td>0.33 to 0.63</td>
</tr>
<tr>
<td>RCP8.5</td>
<td>0.30</td>
<td>0.22 to 0.38</td>
<td>0.63</td>
<td>0.45 to 0.82</td>
</tr>
<tr>
<td><strong>Global Mean Sea Level Rise (m)</strong></td>
<td></td>
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</tbody>
</table>

Notes:

- b: Source: other. 
GLOBAL PREVALENCE OF IRON, ZINC, VITAMIN A DEFICIENCIES IN <5 CHILDREN

Source: HarvestPlus, 2013: http://www.harvestplus.org/content/nutrients