AgMIP The Agricultural Model Intercomparison and Improvement Project

Climate Change Challenges to Agriculture, Food Security, and Health




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Outline

1. Food System and Current Challenges
2. Climate Change Impacts
3. Agricultural Solutions

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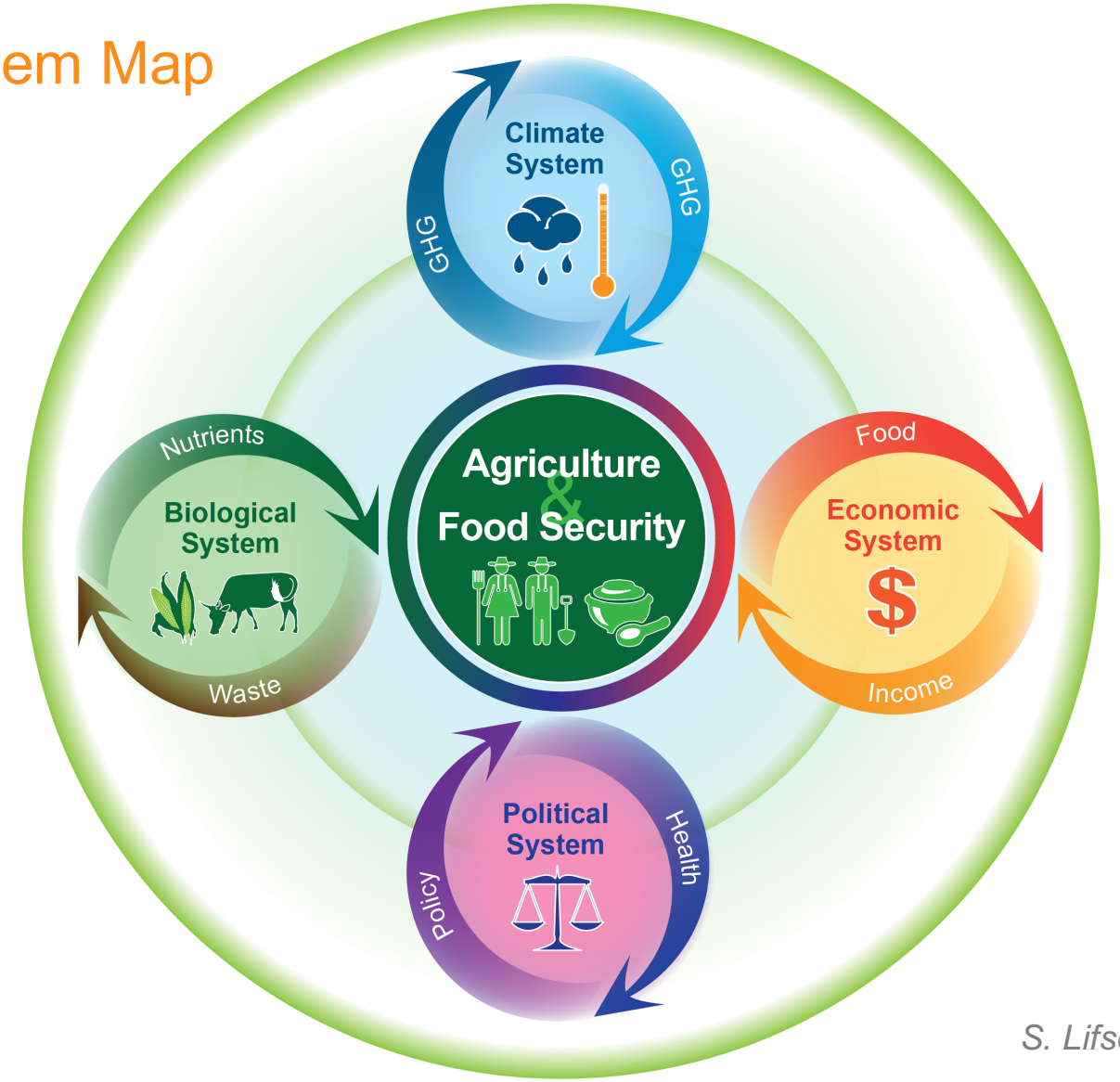
Food System and Current Challenges

Food System Approach

Food System Map



Food Security

Food availability: Sufficient quantities of food of appropriate quality, supplied through domestic production or imports (including food aid).

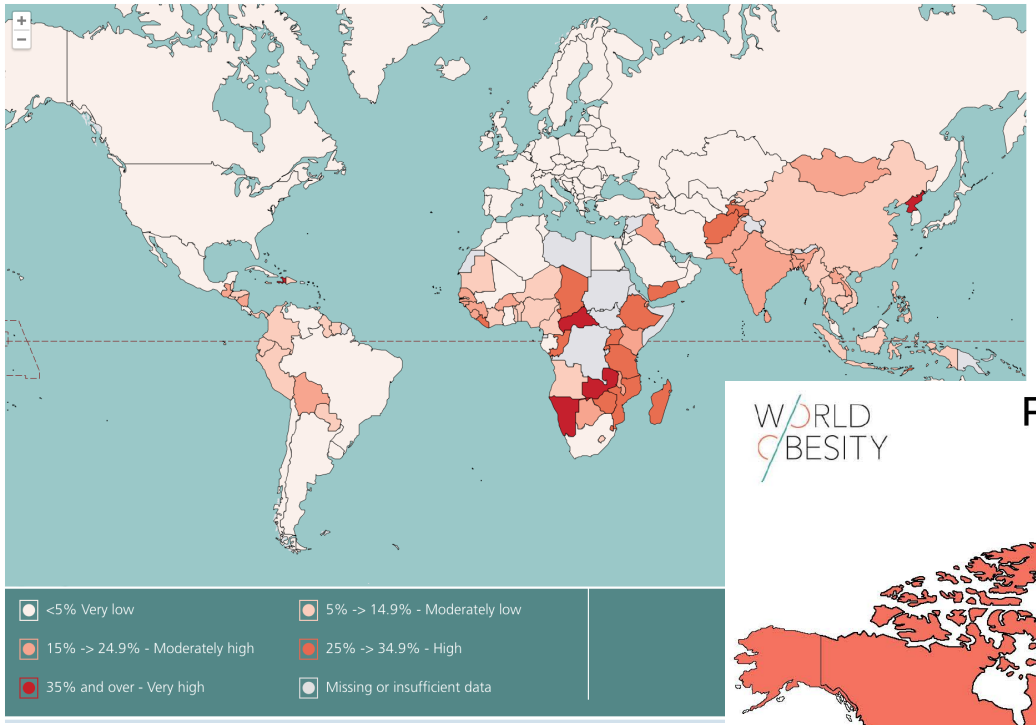
Food access: Access by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet.

Stability: Access to adequate food at all times by a population, household or individual. They should not risk losing access to food as a consequence of sudden shocks.

Utilization: Adequate diet, clean water, sanitation and health care – a state of nutritional well-being where all physiological needs are met.

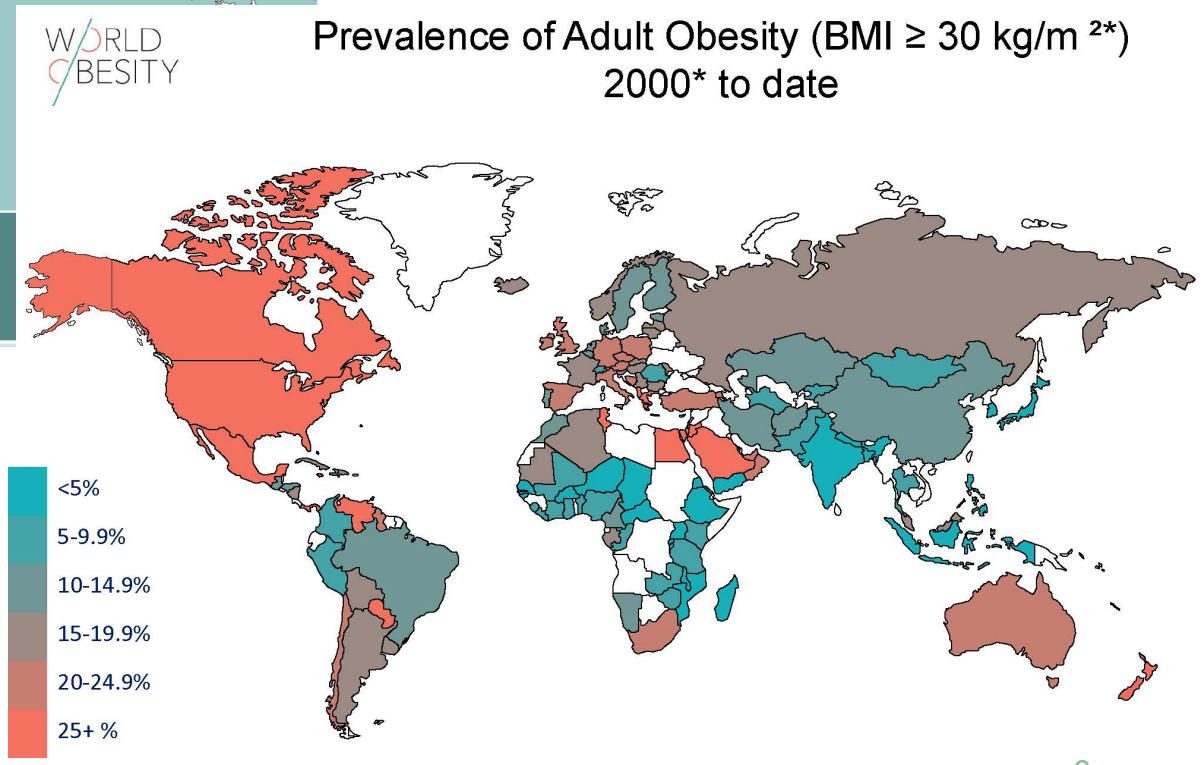
https://ble.lshtm.ac.uk/

Nutrition and Health



FAO Hunger (Chronic Undernourishment) Map 2015

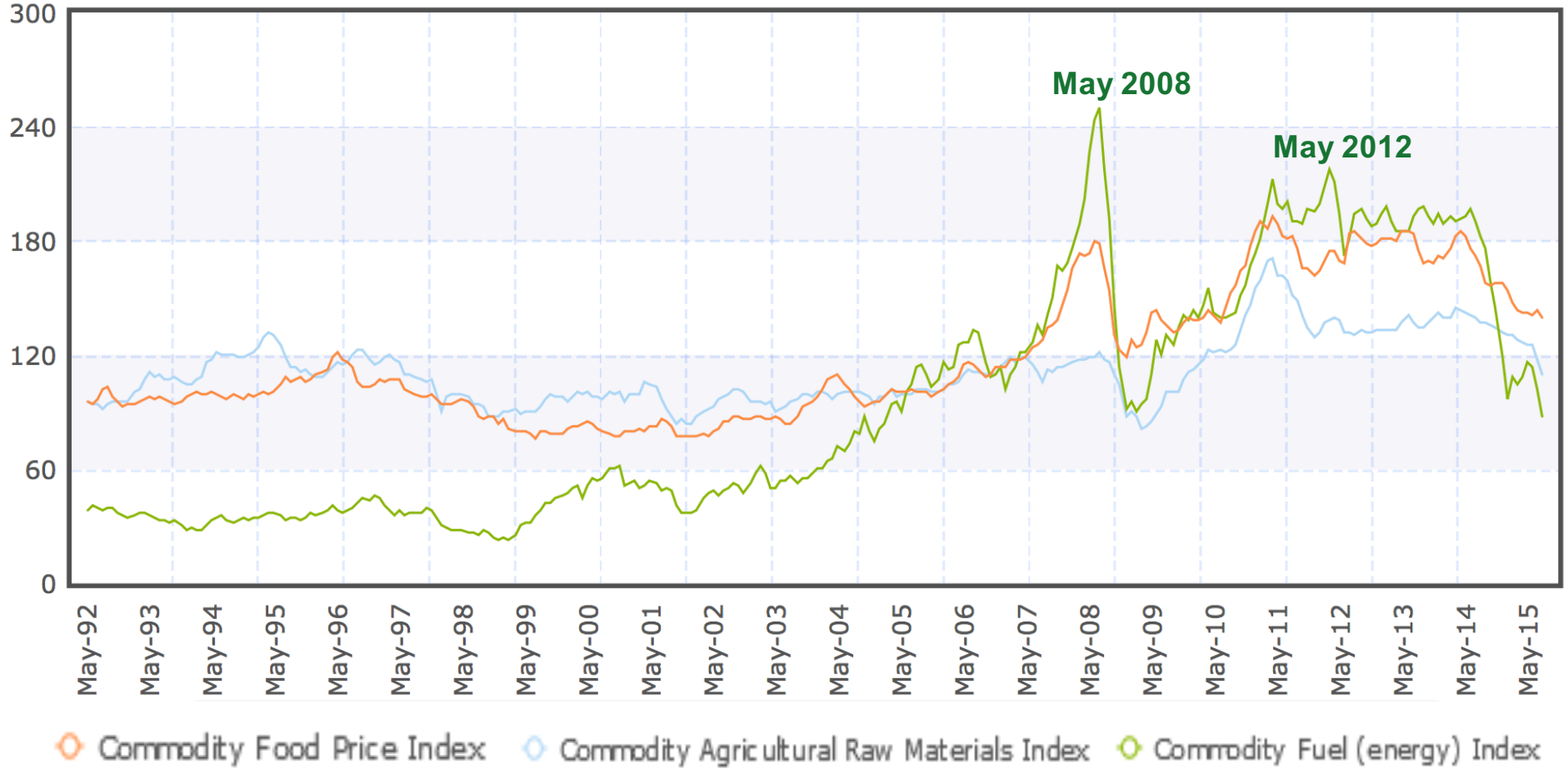
Hunger in the world is still "serious," with 805 million people continuing to go hungry, according to FAO



Obesity is now seen as one of the most important public health problems today, about 475 million adults are obese according to World Obesity

Food Price Spikes

Annual Commodity Price Indices 1992-2015



Source: http://www.indexmundi.com/commodities/

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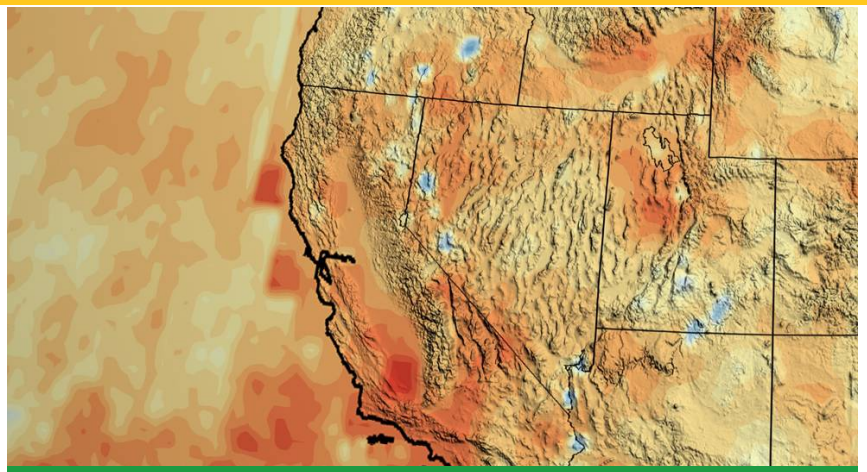
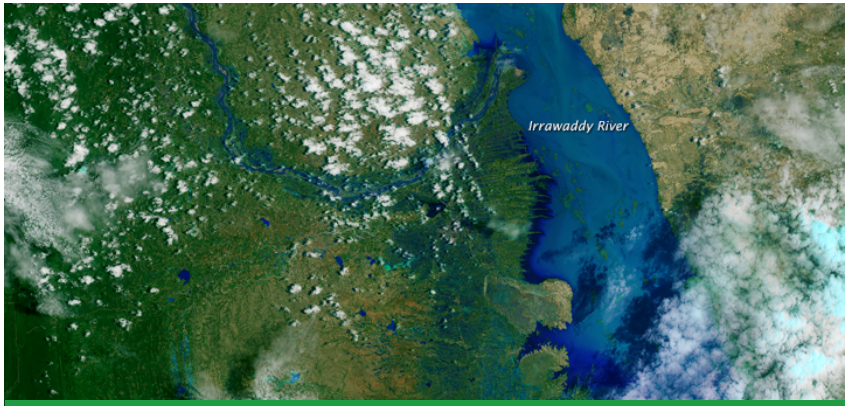
Current Climate Stresses

Corn shows the effect of the drought in Texas in August 2013
U.S. Department of Agriculture/Bob Nichols



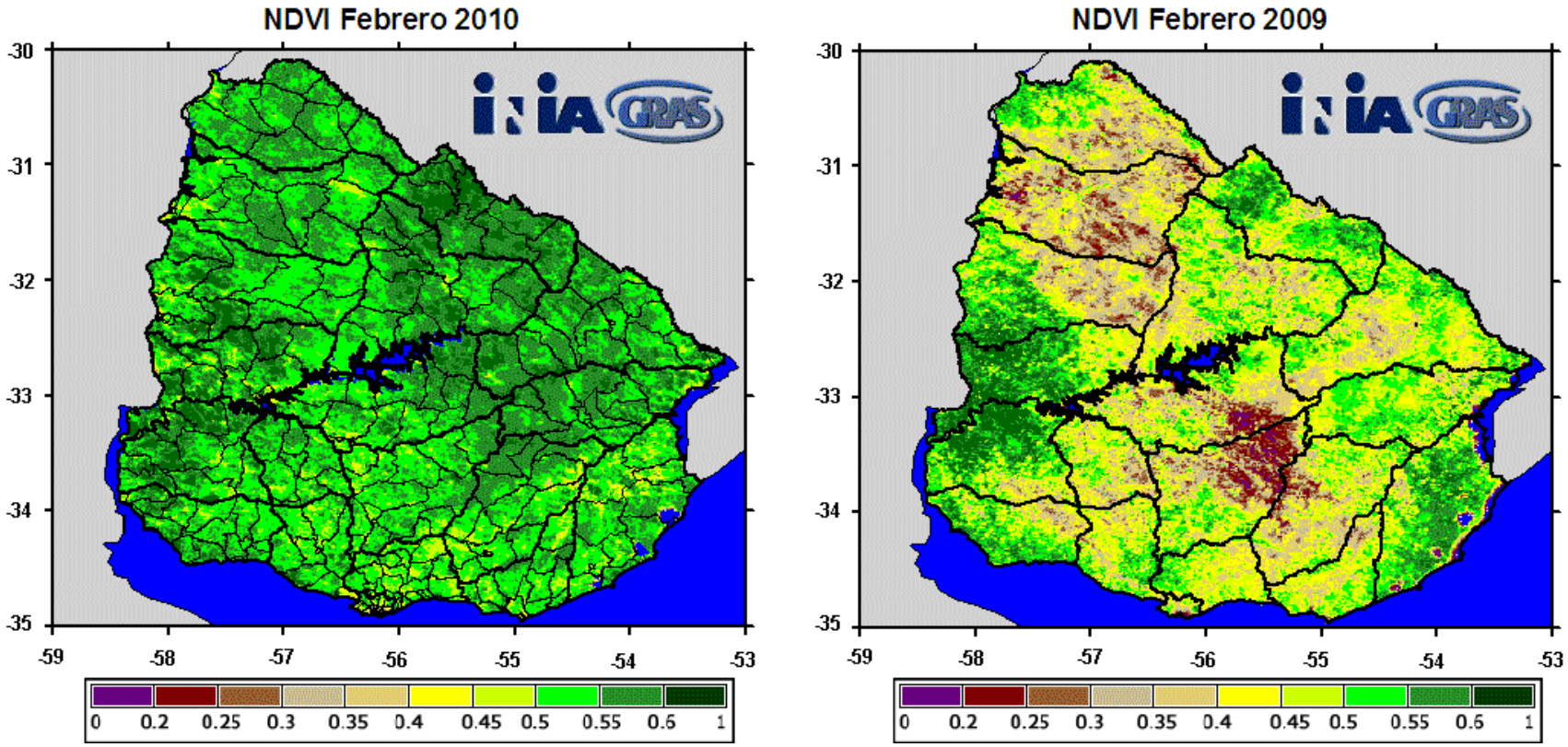
California's accumulated precipitation “deficit” from 2012 to 2014
NASA/Goddard Scientific Visualization Studio



Satellite image of flooding in Burma (Myanmar) August 2015
NASA Earth Observatory images by Joshua Stevens

Severe flooding in August 2015 in Pakistan wipes out harvest
Image:Rueters/London

Major Modes of Variability

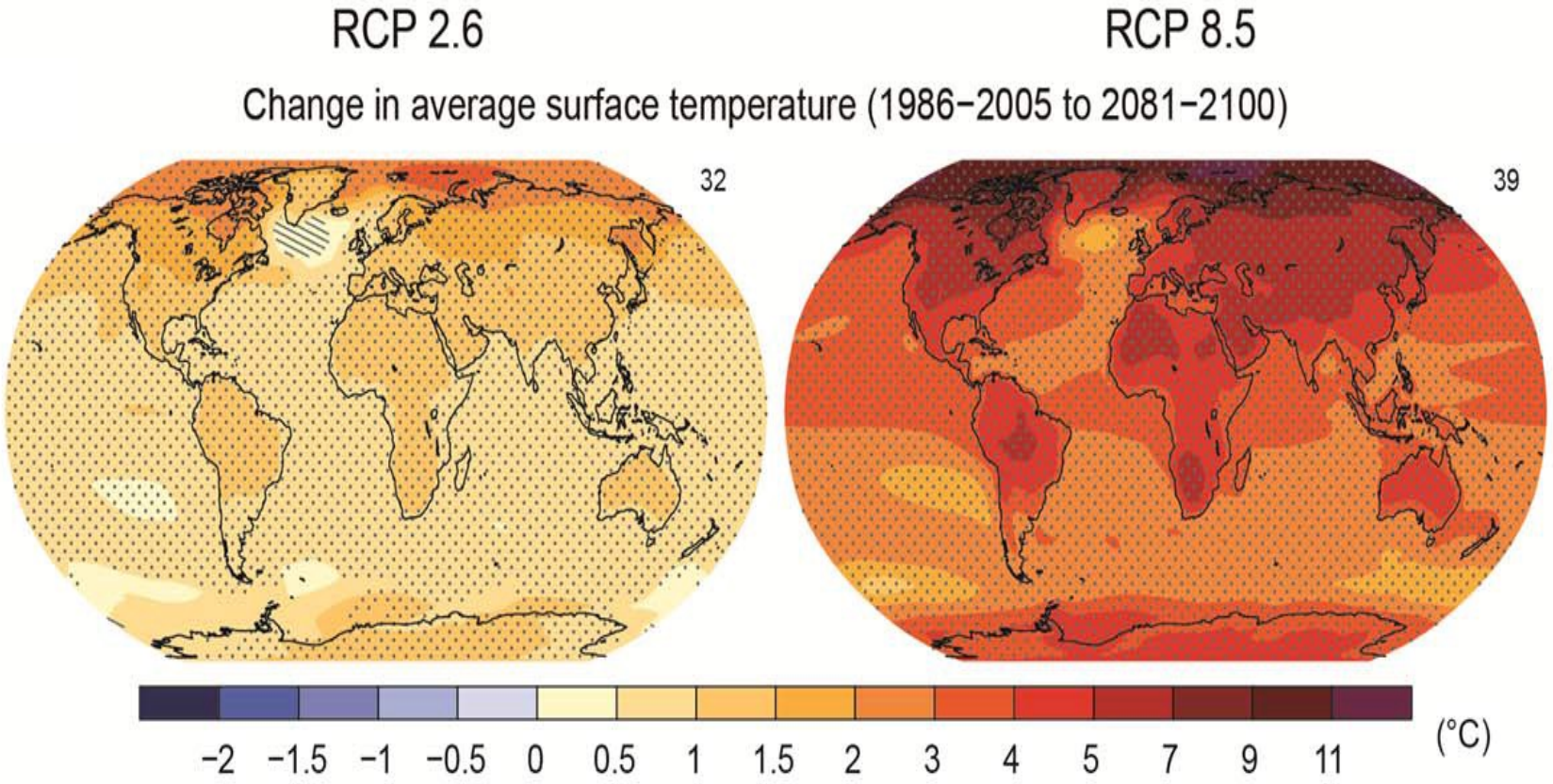


Vegetative Index (NDVI) for El Niño (2010) and La Niña (2009) years in Uruguay. Green = wellwatered; red/purple = drought conditions

Strong El Niño forecast for 2015-2016

(http://www.inia.uy/investigación-e-innovación/unidades/GRAS/Monitoreo-Ambiental/Monitoreo-de-la-vegetación; http://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/)

Climate Change



Hatching = Signal is small compared to noise

Stippling = Signal is large compared to noise and 90% of models agree

IPCC AR5 Temperature Projections

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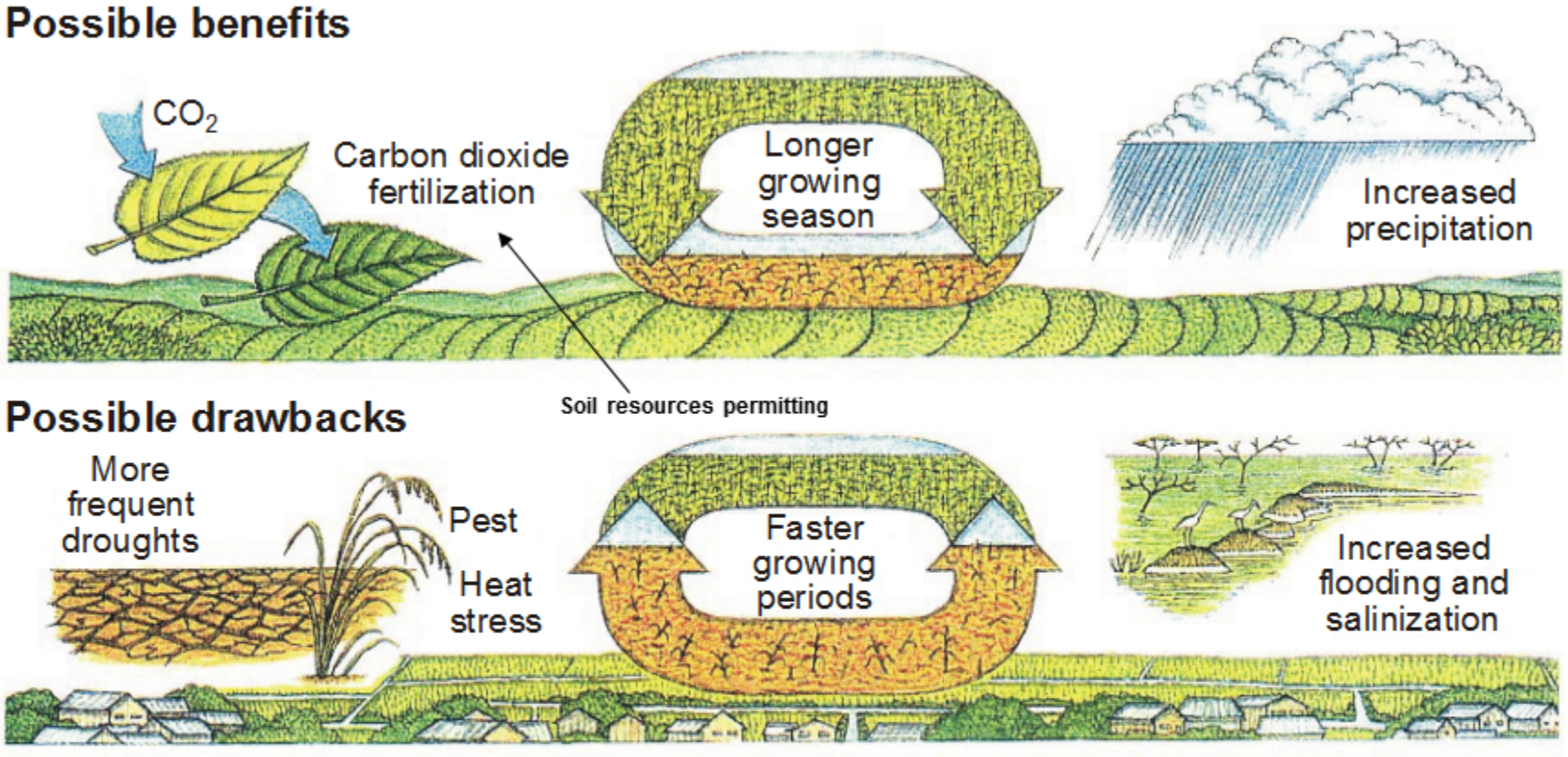
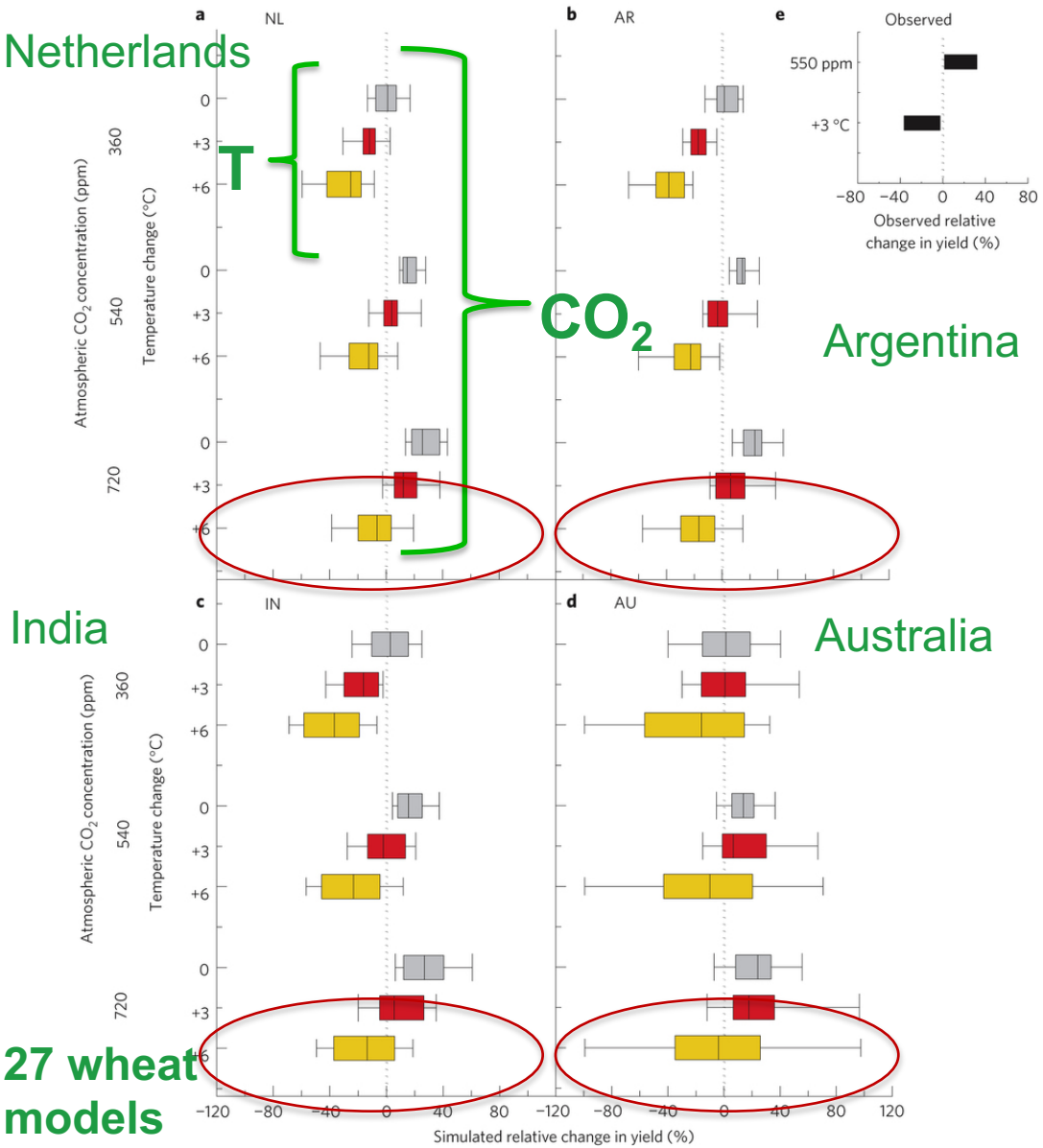
Climate Change Impacts

Climate Change Impacts – Agriculture



Bongaarts, J., Scientific American, 1992

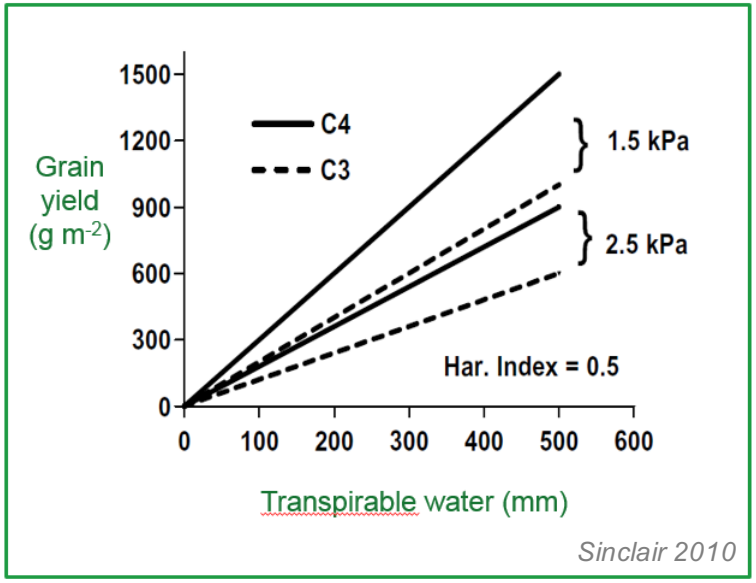
Temperature and CO_2 Effects



- AgMIP Wheat Model Intercomparison
- Decline in yields with higher temperatures
- CO_2 a positive factor
- But potential for significant yield declines even with high CO_2

Asseng et al., 2013 Uncertainty in simulating wheat yields under climate change ***Nature Climate Change***

Yield Response to Water

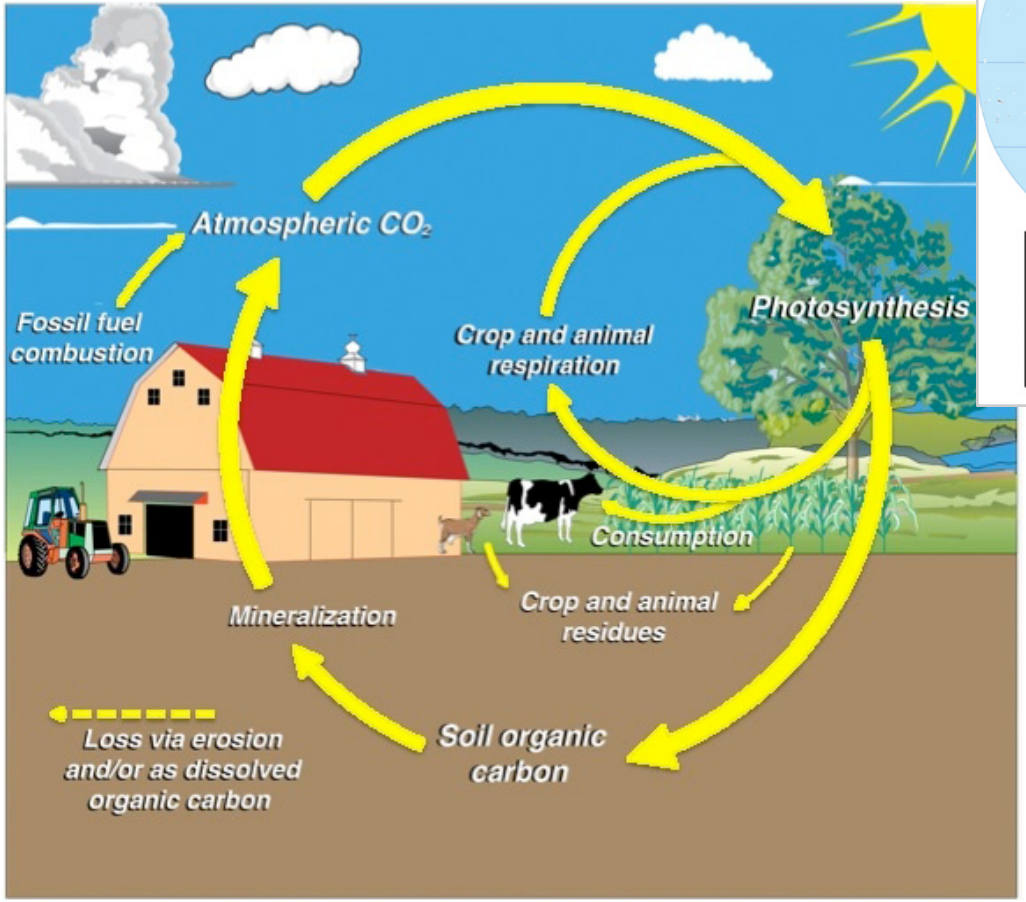


Maximum grain yield plotted as a function of the amount of transpirable soil water available through the growing season. Two vapor pressure deficit environments are presented.

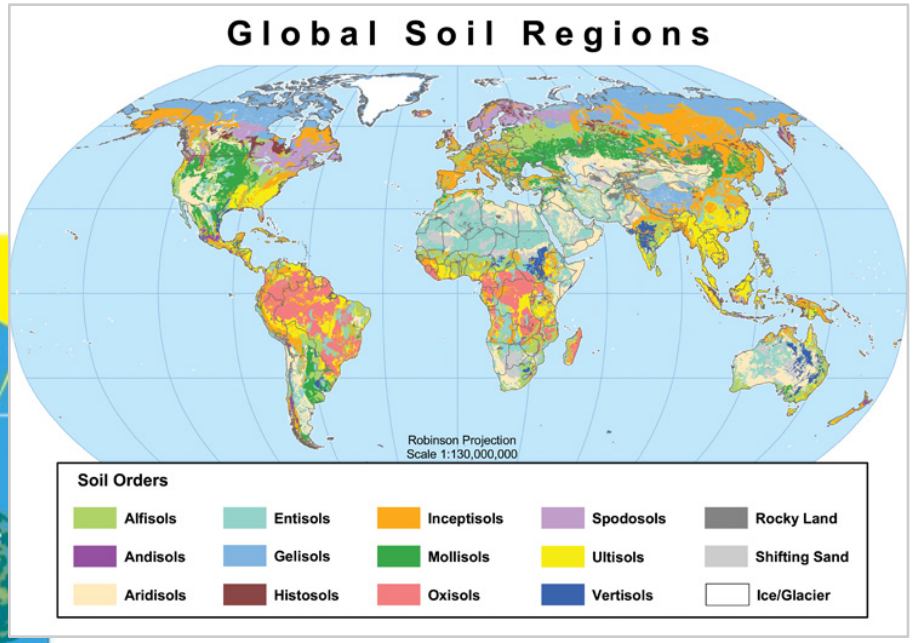
- Crops need water – through precipitation or irrigation
- Drought stress affects yield during critical growth periods
- Excess water can be damaging as well
- C4 crops – e.g., corn and sorghum – favored at both higher and lower water stress

Effects on Soils

Carbon Cycling in Agroecosystems



A.Y.Y. Kong et al.

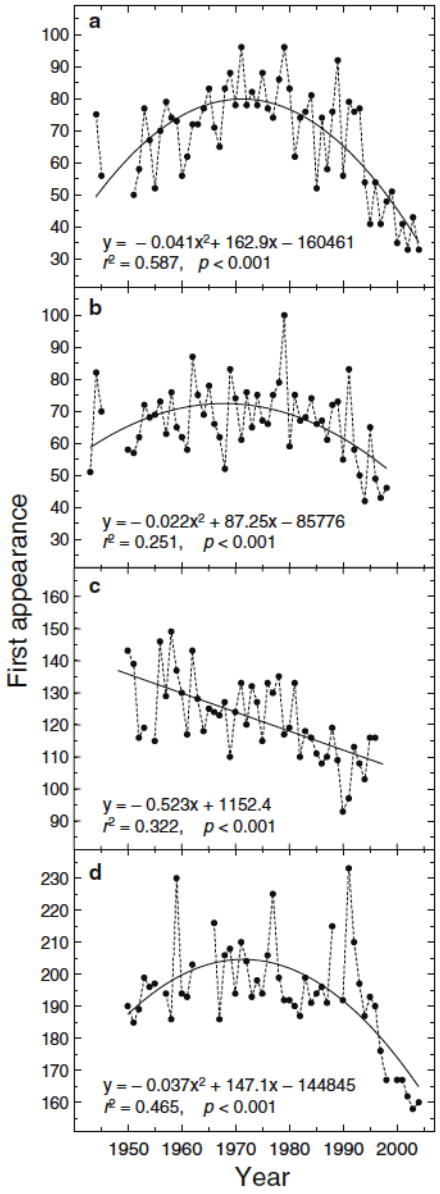


Source: USDA

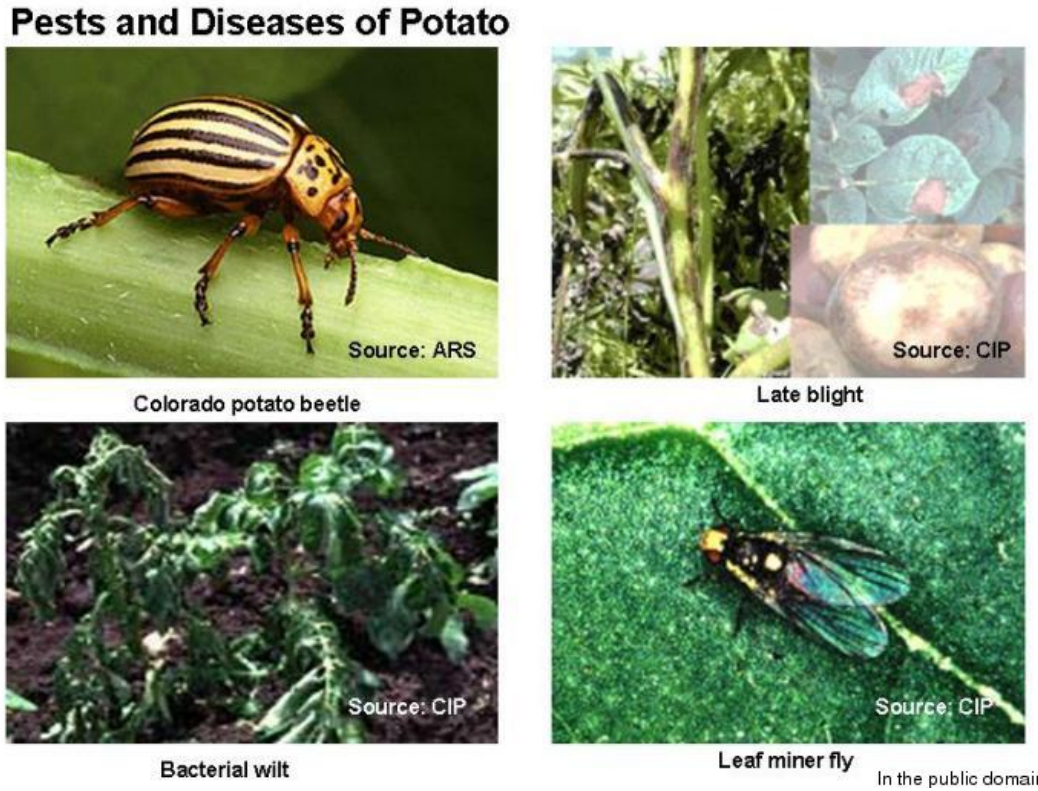
- High temperature effects on soil biological and chemical processes
- Water-logging from increased heavy downpours

Pests and Diseases

Changes in climate and extreme events could have significant effects on the damage caused by and location of agricultural pest and diseases.

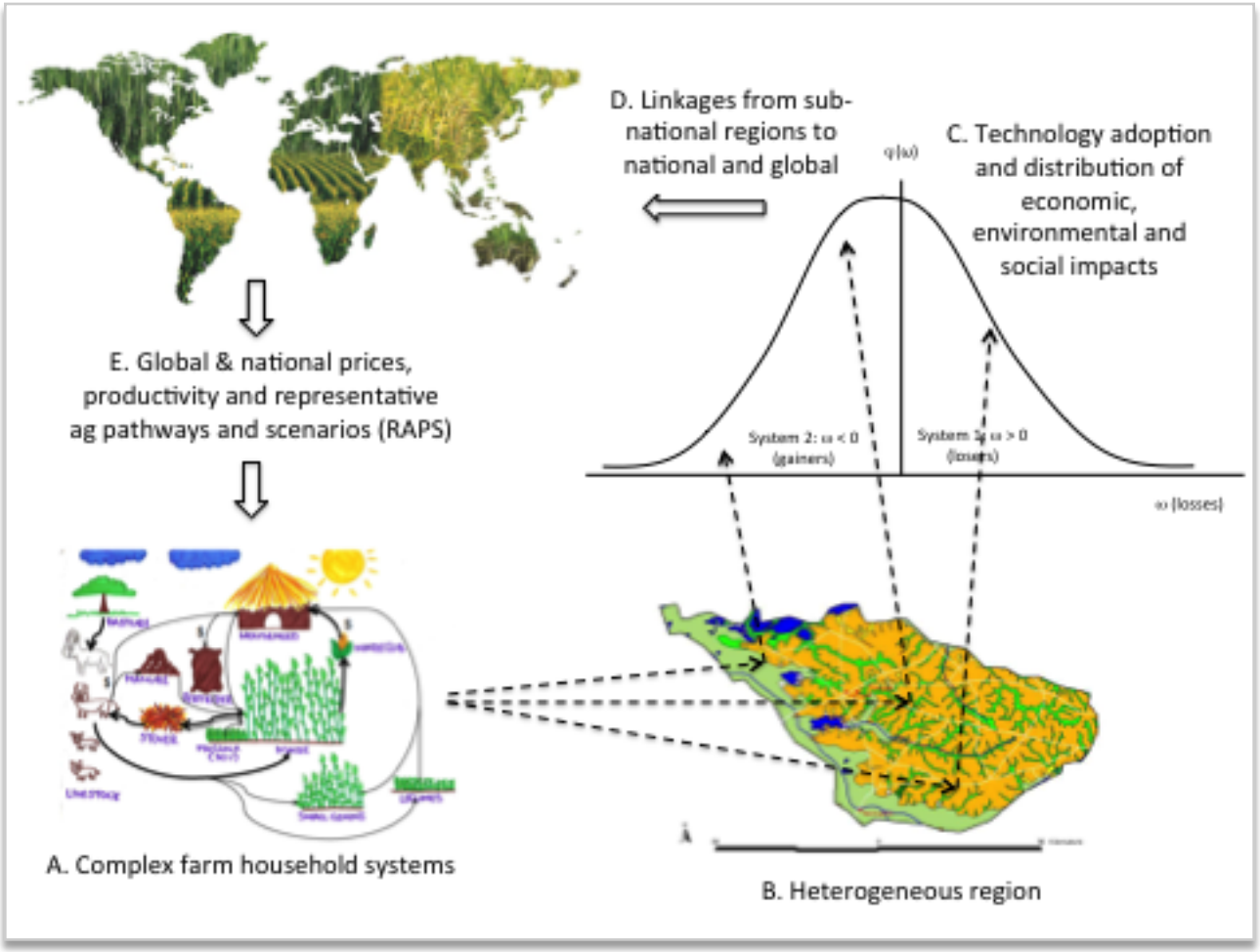


Time of first appearance of four insect species at Tortosa, Spain (1943-2004) *Gordo and Sanz, 2005, Gutierrez et al., 2011*



In the public domain.

AgMIP Regional Integrated Assessment – 5 Attributes



- Farming systems
- Transdisciplinary: physical, biophysical, and socio-economic
- Multi-scale: field, farm, region, global
- Multiple climate and crop models
- Distributional results: impacts on poverty

Antle et al., 2015

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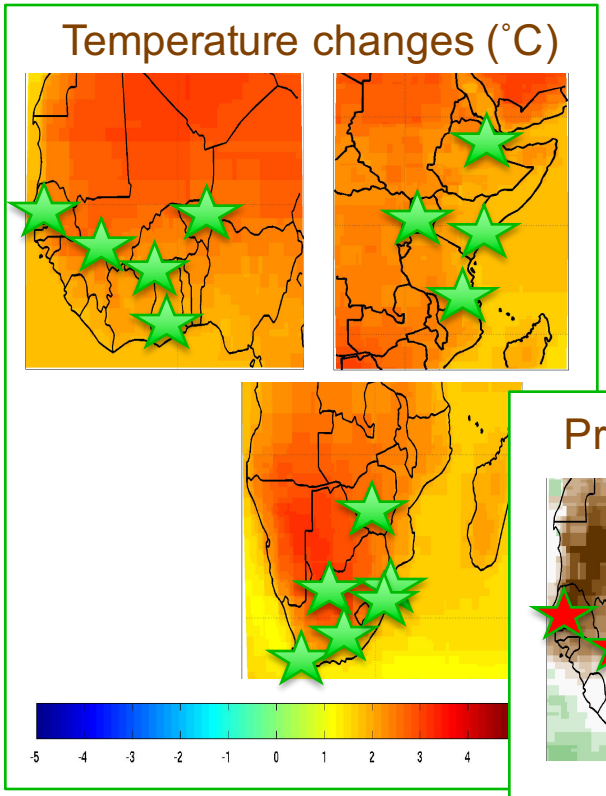
Assessments Driven by Local Climate Change Projections

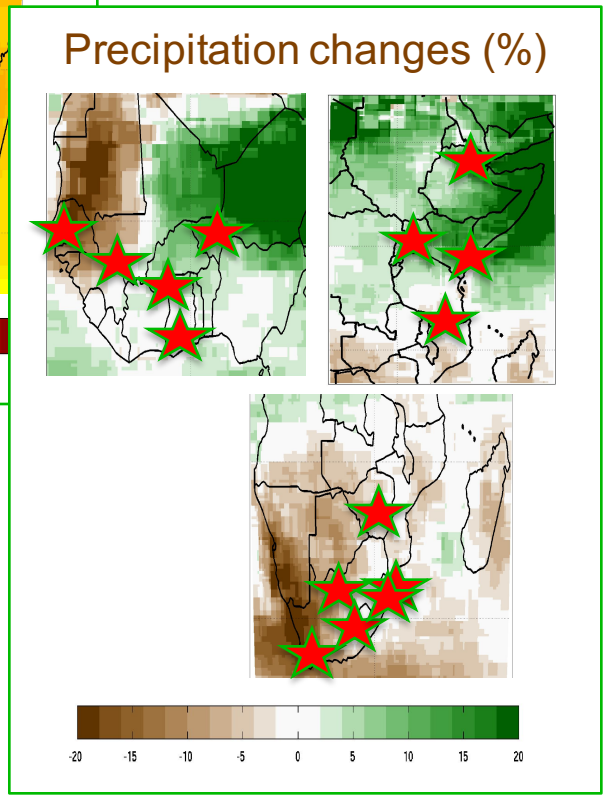


AgMIP Scenarios

Extreme Events

Monsoon

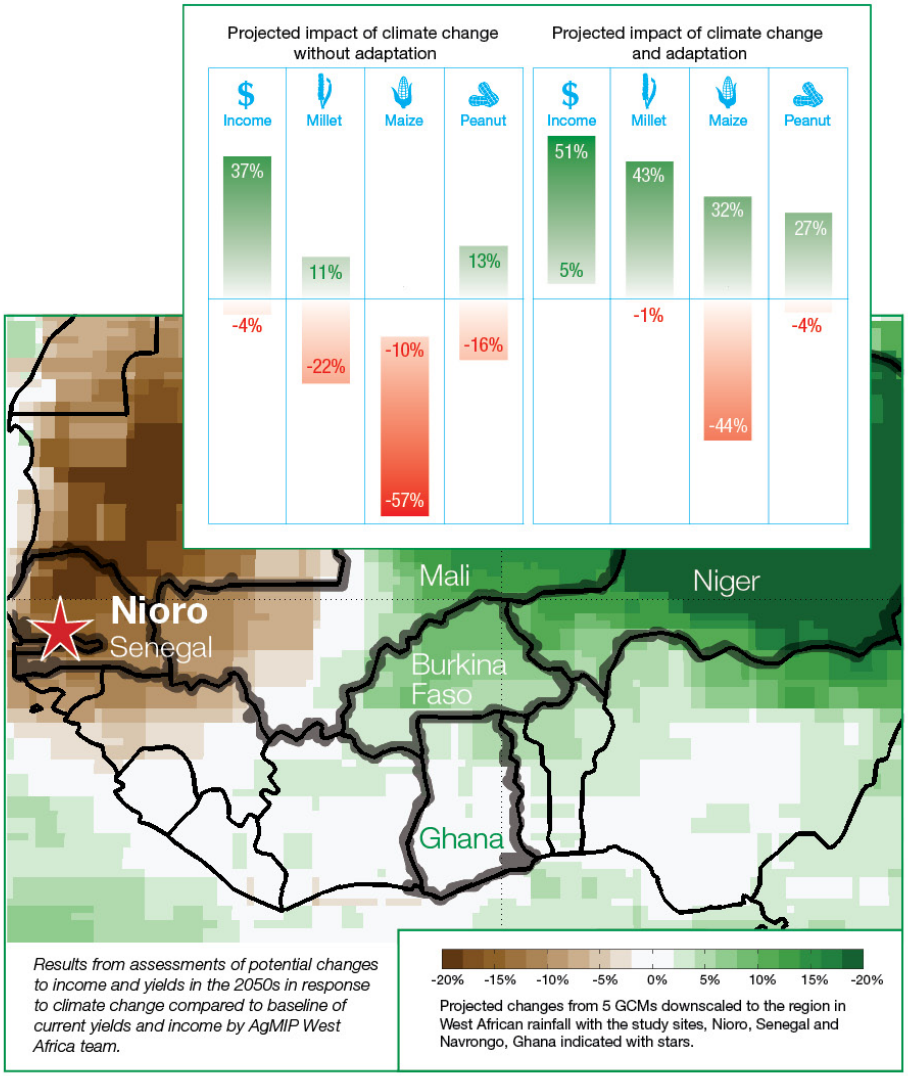
Near-term Scenarios



West Africa Climate Change Impacts

Adaptation packages can raise incomes and lower poverty rates,

but do not always compensate completely



Adiku et al., 2015

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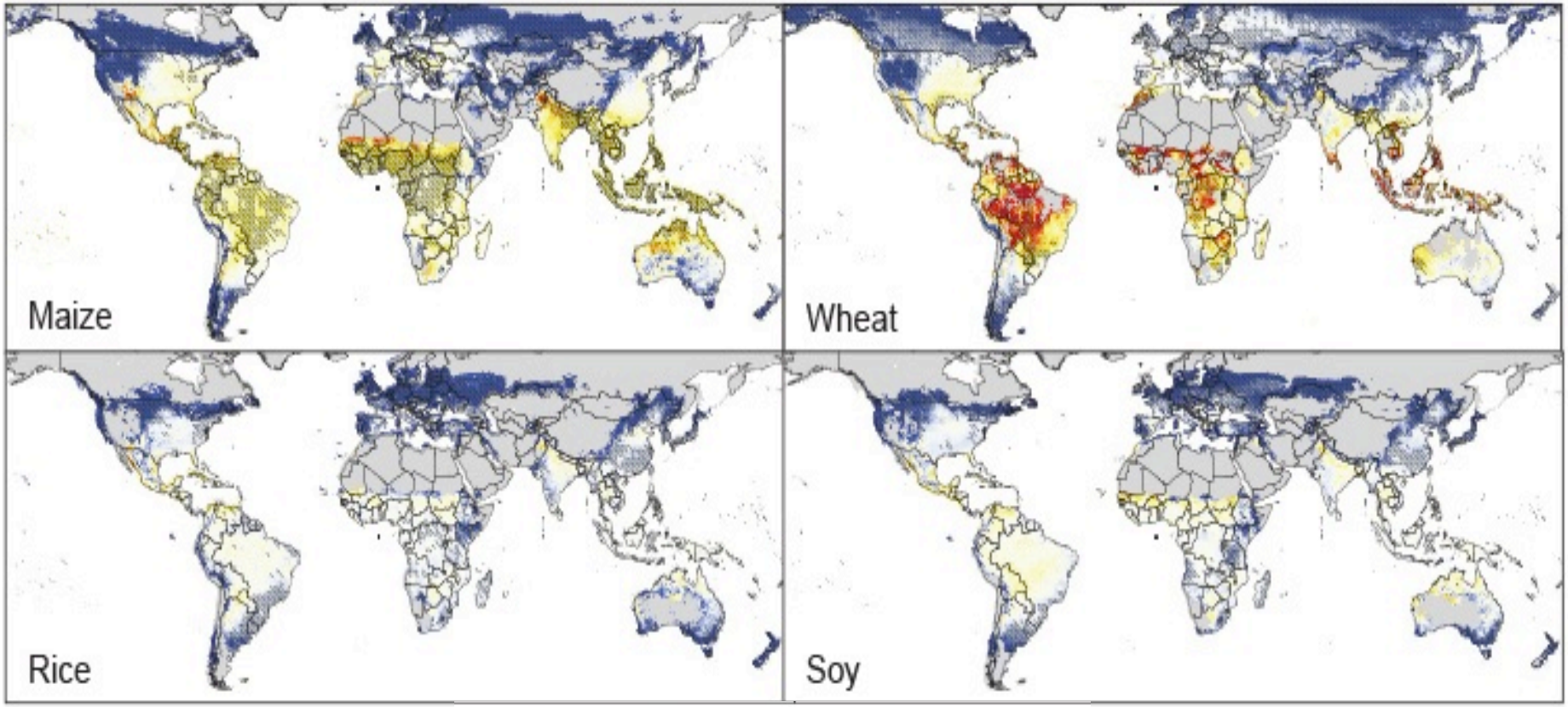
Effects on Global Crops

Rosenzweig et al., PNAS, 2013



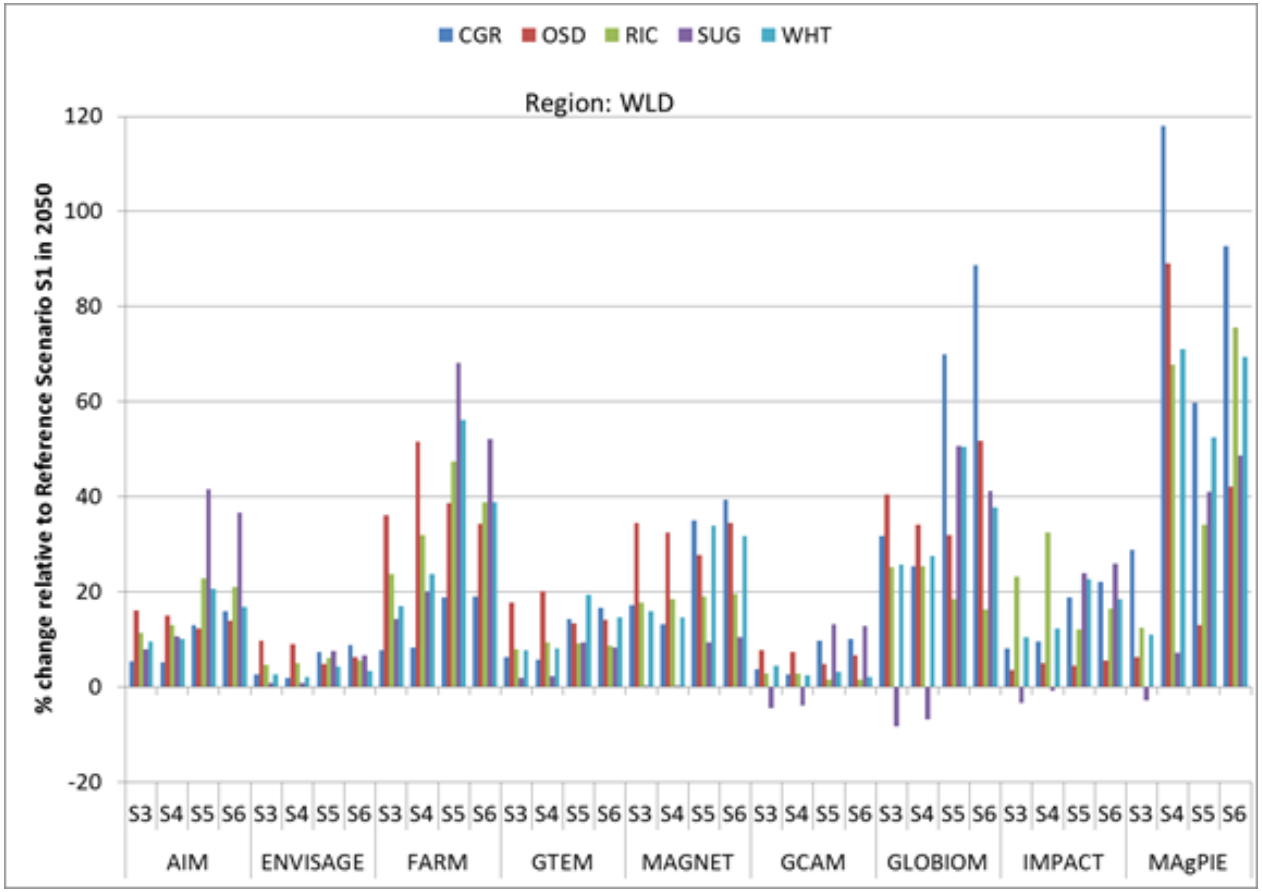
Hatched areas indicate
>70% model agreement

2080s

median of 7 GGCMs and 5 GCMs/AgMIP led agricultural contribution to ISIMIP

Lower latitudes are more vulnerable to climate change
Results comparable to AR4

Effects of climate change on agricultural prices



Nelson, Gerald C. et al., "Agriculture and Climate Change in Global Scenarios: PNAS; Agricultural *Economics, 2013*

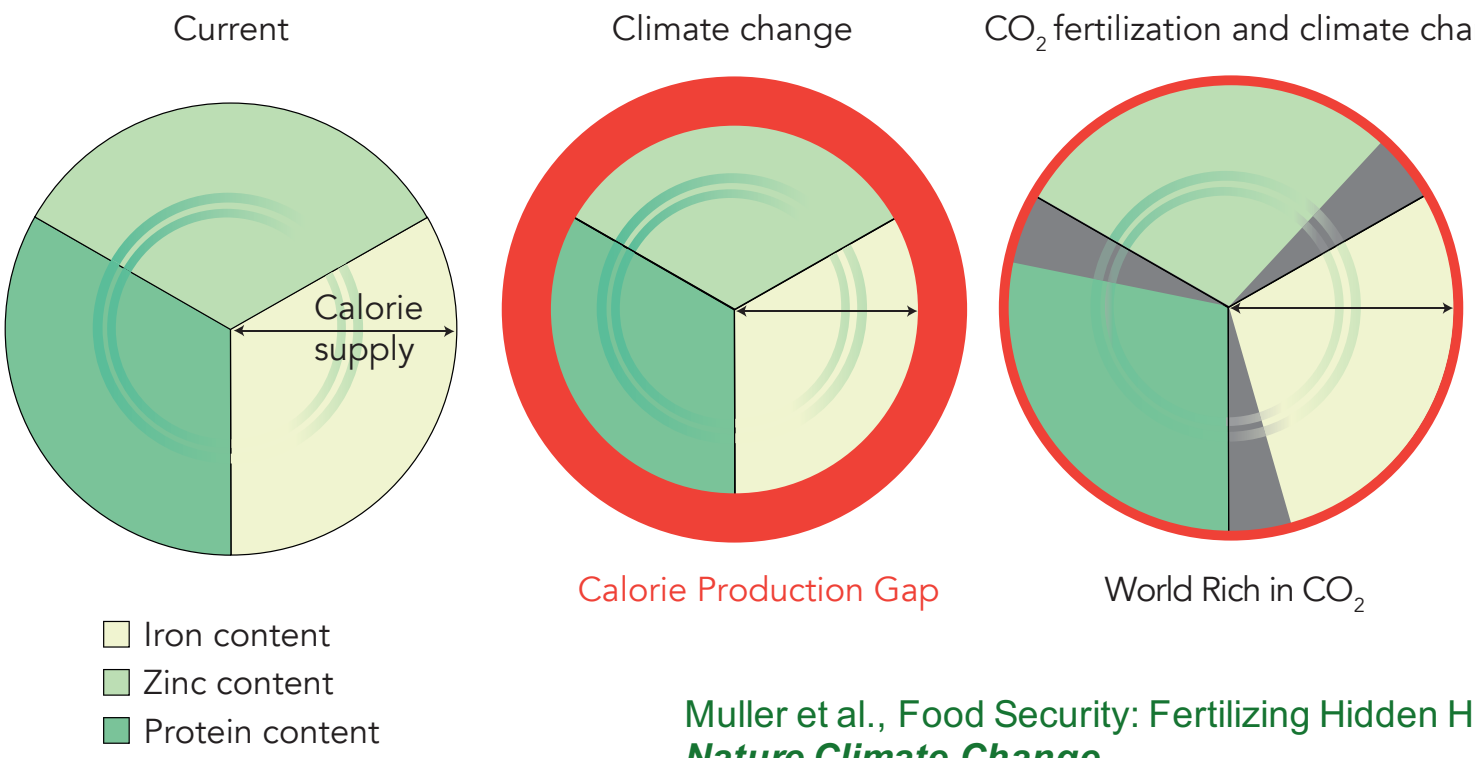
Phase 2 workshop in Dublin April 9, 2013

9 global economic models

Source: AgMIP model runs, December 2012

There is potential for large price increases with climate change, although uncertainty is also large

Effects on Nutrition and Health



Muller et al., Food Security: Fertilizing Hidden Hunger
Nature Climate Change

Climate change alone decreases calories –
CO_2 effects restore calories but decrease nutritional content

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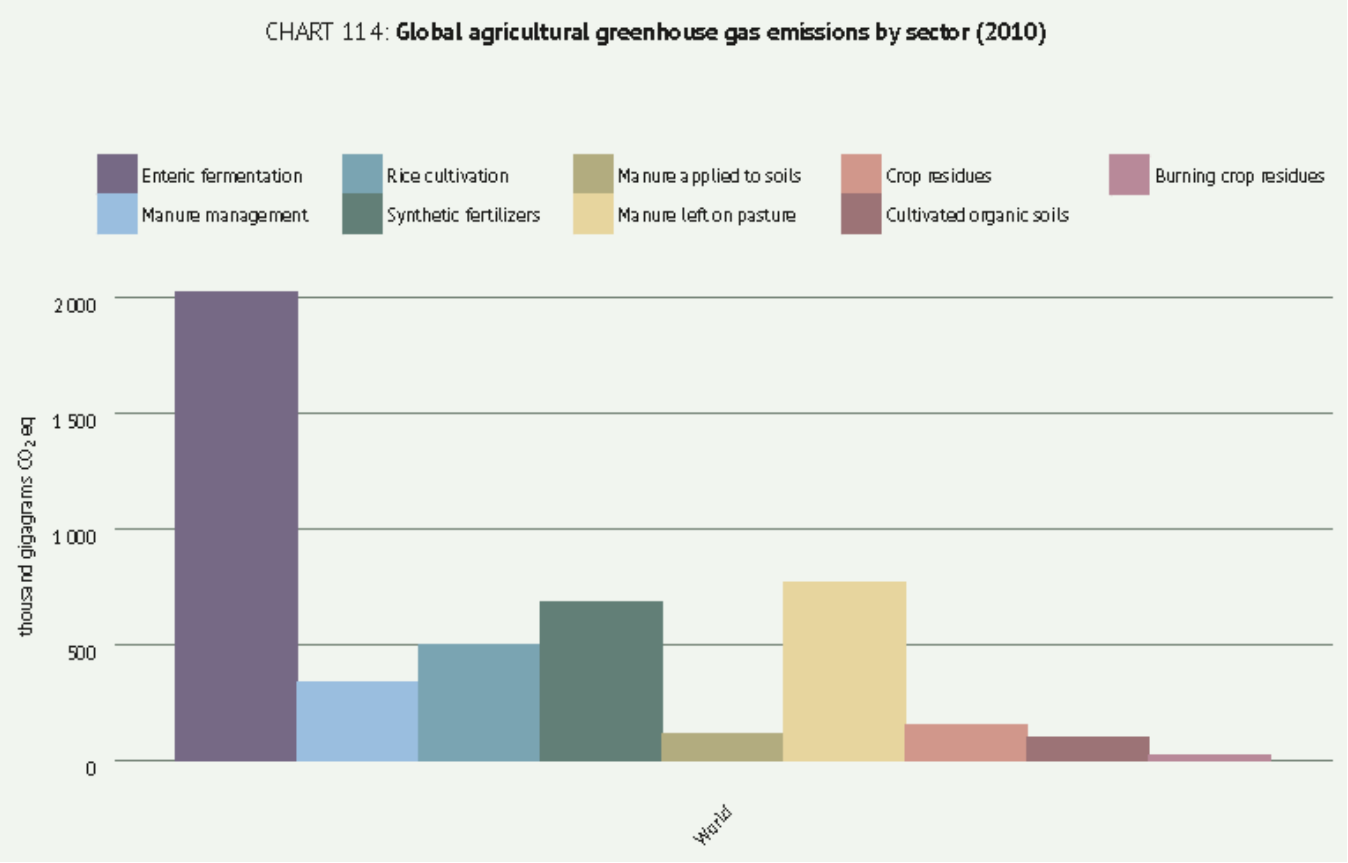
Agricultural Solutions

GHG Emissions – Agriculture Sector



FAO Statistical Yearbook 2013 – World Food and Agriculture

Enteric fermentation 42%

Manure left on pasture 16%

Rice cultivation 10%

Synthetic fertilizers 14%

Manure management 8%

Other 10%

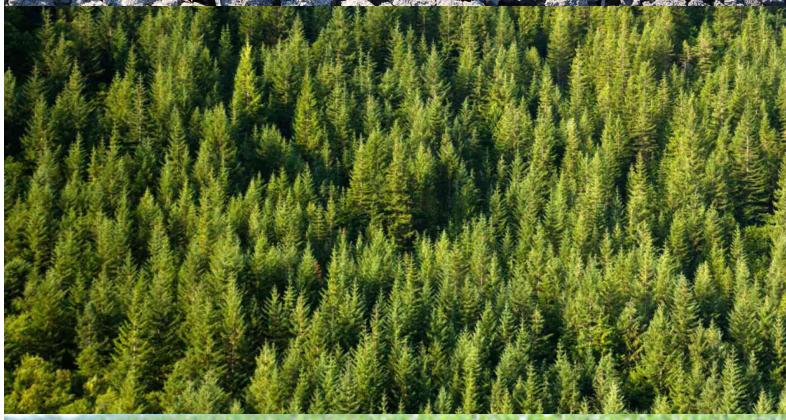
14% of total GHGs from ag +
12% from land use change = ~26% total

Agricultural solutions for mitigating climate change

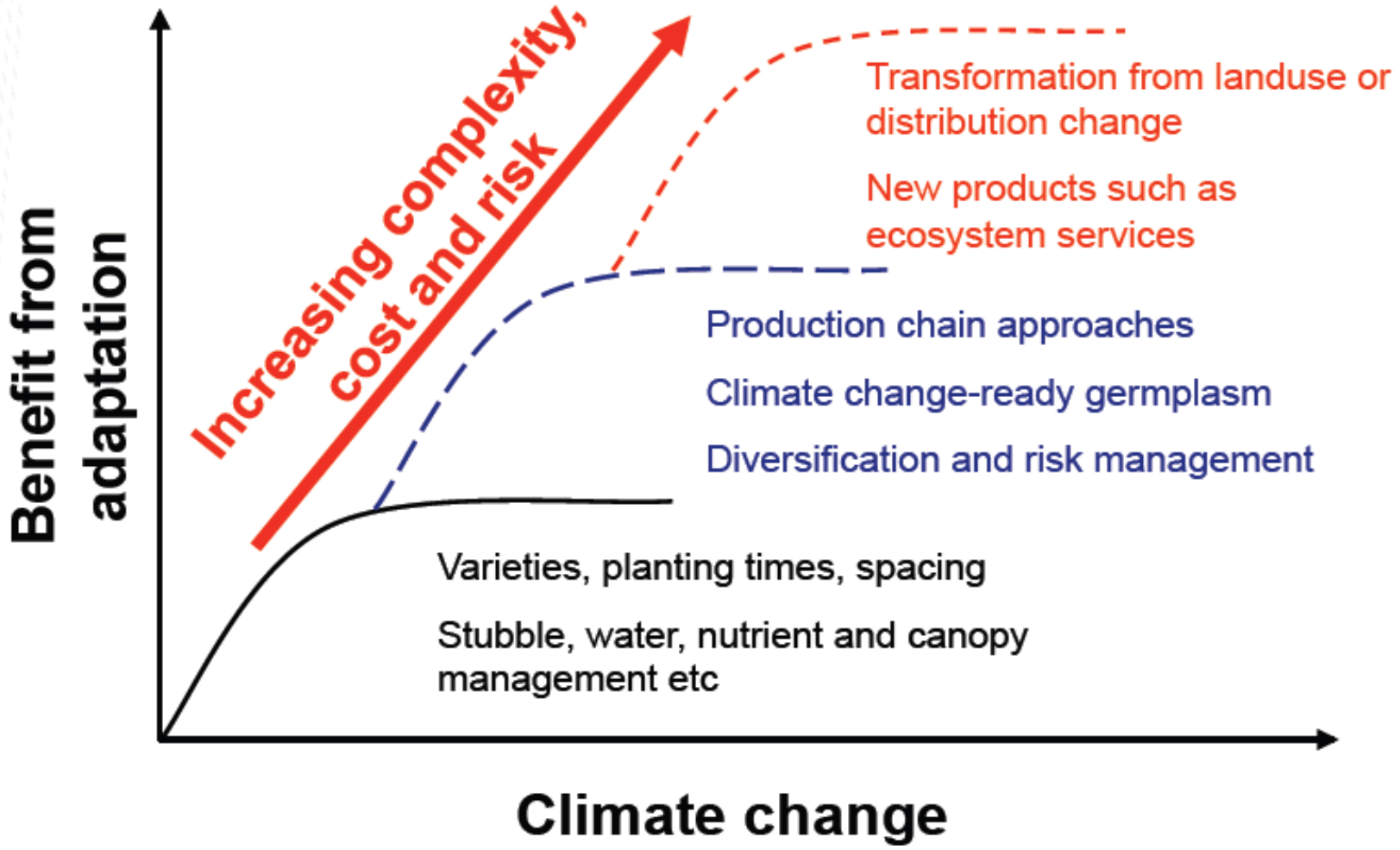
Soil Carbon Sequestration – has the possibility of sequestering carbon at a cost competitive with other methods of reducing GHG emissions. *(Center for Climate and Energy Solutions)*

Biomass Carbon Sequestration – Agroforestry can play a role in carbon sequestration and mitigating CO_2 emissions. *(USDA)*

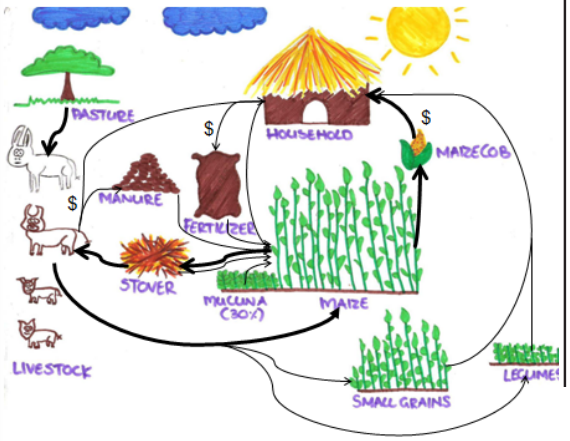
Biofuels – With the exception of ethanol made from corn, use of biomass to produce heat, power, or fuels can result in zero or close to zero CO_2 emissions. *(Center for Climate and Energy Solutions)*



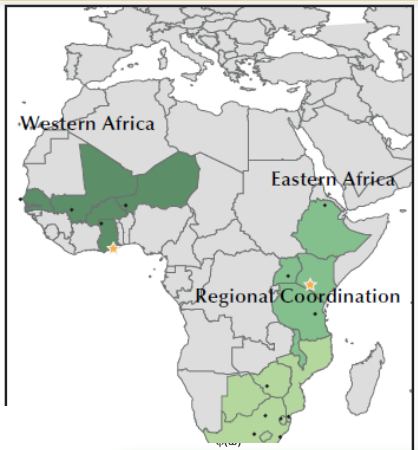
Progressive Levels of Adaptation Challenges and Opportunities

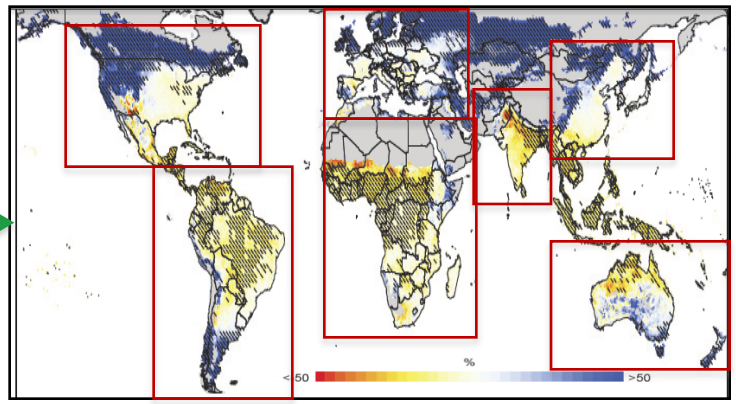


Howden, 2010



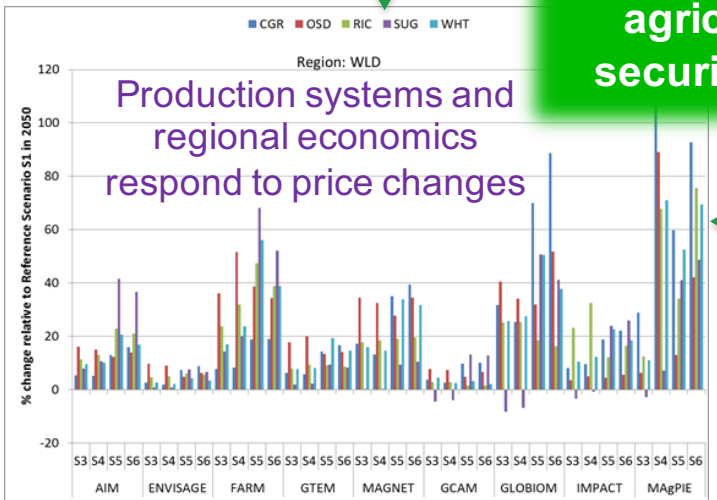
RRTs – Farming systems biophysical and socioeconomic models





GGCMI -- High-resolution gridded crop modeling for gap-filling and aggregation in each region

Goal
Significantly improved understanding of climate change impacts on agriculture, food security, and health



Production systems and regional economics respond to price changes

Global Economics – Model analysis of world and regional prices

Conclusions

Farmers and others in the agricultural sector are faced with the quadruple task of contributing to global reductions of carbon dioxide and other greenhouse gas emissions, coping with an already-changing climate, delivering healthy nutritious food, and sustainably managing soil and water resources.

In short, agriculture is being called upon to ensure both human and planetary health.

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For protocols, up-to-date events and news, and to join AgMIP listserve – www.agmip.org