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SETTING THE TABLE FOR A HOTTER | FLATTER | MORE CROWDED EARTH

SONNY RAMASWAMY

BIOTIC

ABIOTIC

FOOD
WASTE/LOSS

FARMING
SYSTEMS

POLICIES

PATH
FORWARD



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also Wicked Problems societal challenges

- Population
- Food
- Water
- Environment
- Climate Change
- Energy
- Health
- Poverty





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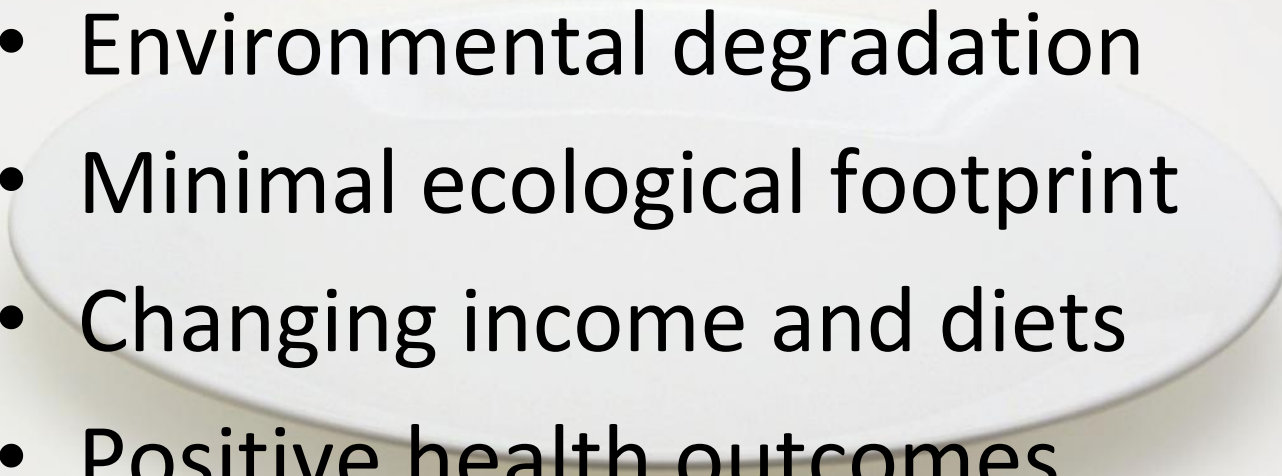
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21st Century Food System Challenges

- Agricultural Competitiveness
 - Improve crop and animal agriculture; enhance farm productivity and income; policies; supply chain; storage; transportation
- Ecological Footprint
 - Water/land use, natural resource and environmental stewardship, greenhouse gas, global climate change, depleted soils
- Bioeconomy
 - Replacements for petroleum-based products and enhance community economic well being
- Health
 - Food safety, nutrition, obesity, type II diabetes, cardiovascular disease, dementia, cancer, hunger, poverty, families/children

Feed, shelter, clothe > 9 billion

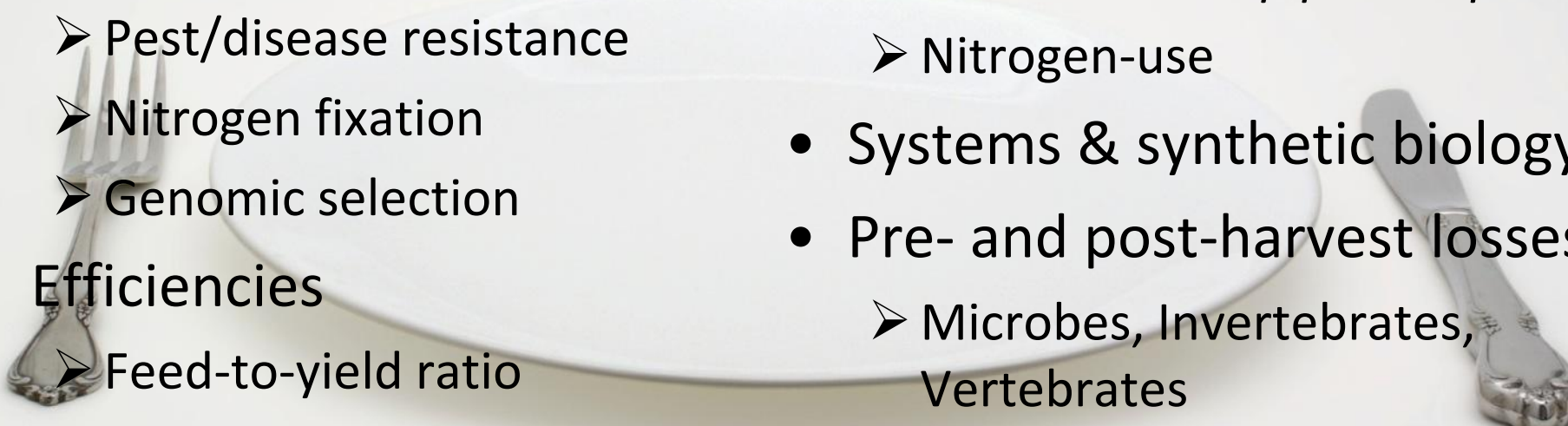
- Climate change
- Land and water constraints
- Increasing urbanization
- Environmental degradation
- Minimal ecological footprint
- Changing income and diets
- Positive health outcomes



The Nexus



Biotic Constraints

- 
- Diversity of species
 - 50,000 edible; 15-50 used
 - Traits
 - Yield/productivity
 - Yield stabilization: GxExM
 - Pest/disease resistance
 - Nitrogen fixation
 - Genomic selection
 - Efficiencies
 - Feed-to-yield ratio
 - Heat tolerance
 - Photosynthesis: *C3 to C4*
 - Scarecrow gene (Siwinski and Turgeon 2013)
 - Cisgenics vs Transgenics
 - Water-use: *Crop per Drop*
 - Nitrogen-use
 - Systems & synthetic biology
 - Pre- and post-harvest losses
 - Microbes, Invertebrates, Vertebrates



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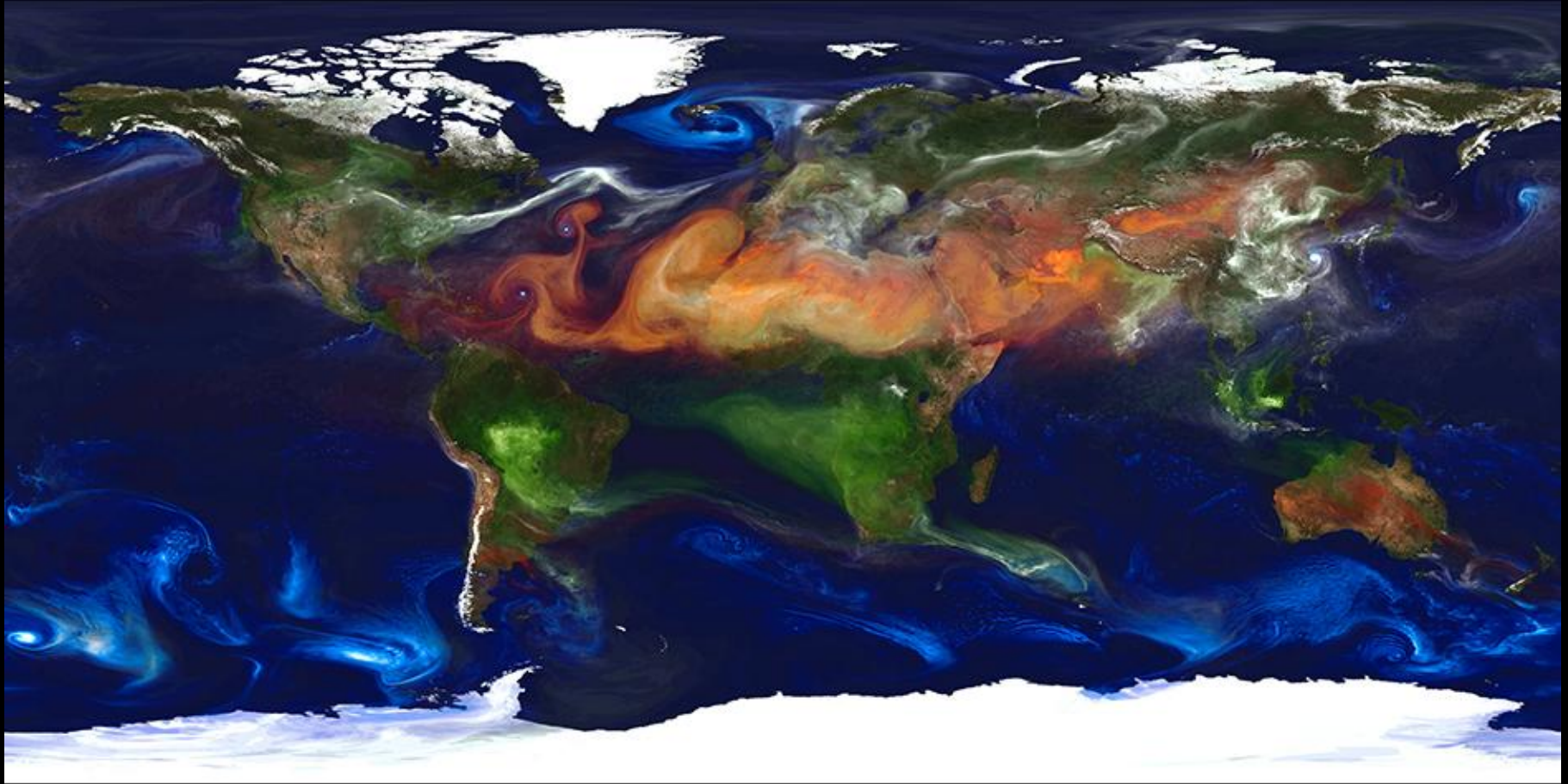
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Abiotic Constraints

- Soil depletion
- GHGs and Climate Change



Portrait of Global Aerosols



Portrait of global aerosols produced by a GEOS-5 simulation. Dust (red) is lifted from the surface, sea salt (blue) swirls inside cyclones, smoke (green) rises from fires, and sulfate particles (white) stream from volcanoes and fossil fuel emissions. *Image credit: William Putman, NASA/Goddard*

Abiotic Constraints

- Soil depletion
- GHGs and Climate Change
- Correlation between yield and temperature
 - 4°C increase: crop failures, malnutrition
 - Livestock/aquatics responses



P 286

IPCC climate crop model ensemble with risk averse crop declines added (red)

Best-fit polynomials

Rain fed reduced
precipitation

Best fit most risk
averse added

Lines are best-fit
polynomials and are
used here as a way to
summarise results
across studies rather
than as a predictive
tool.

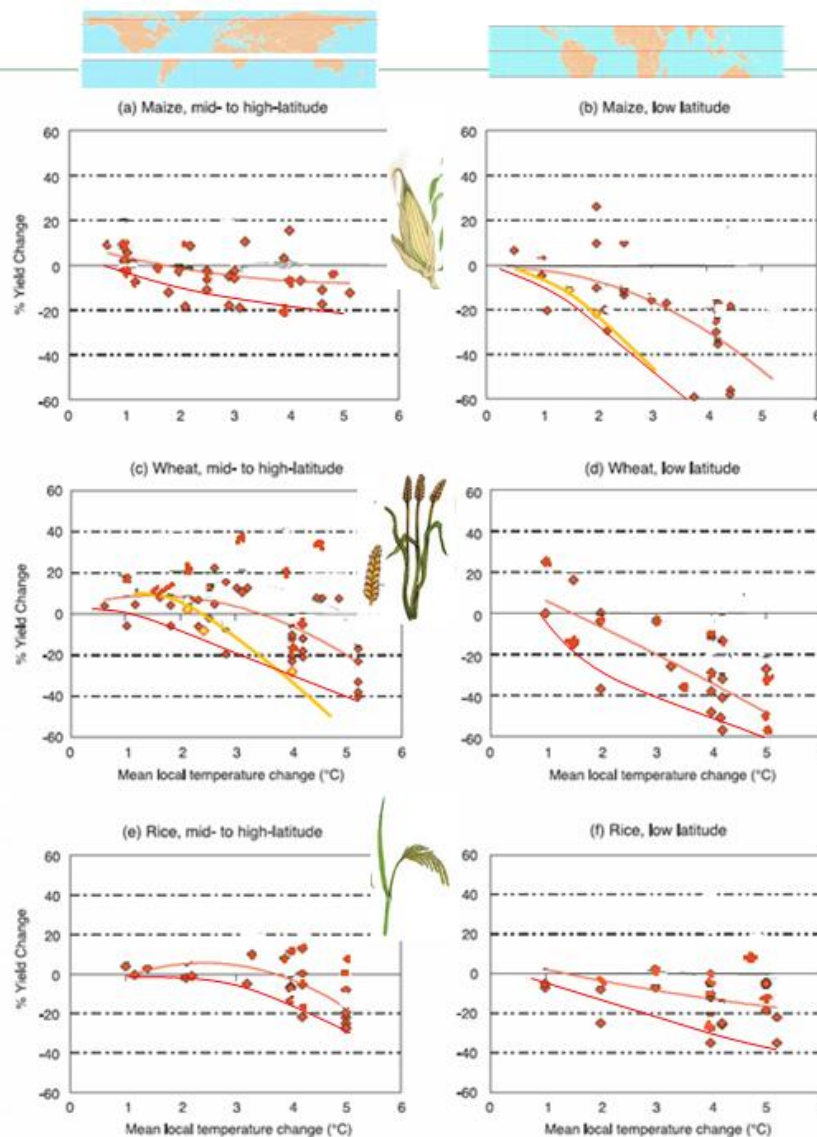


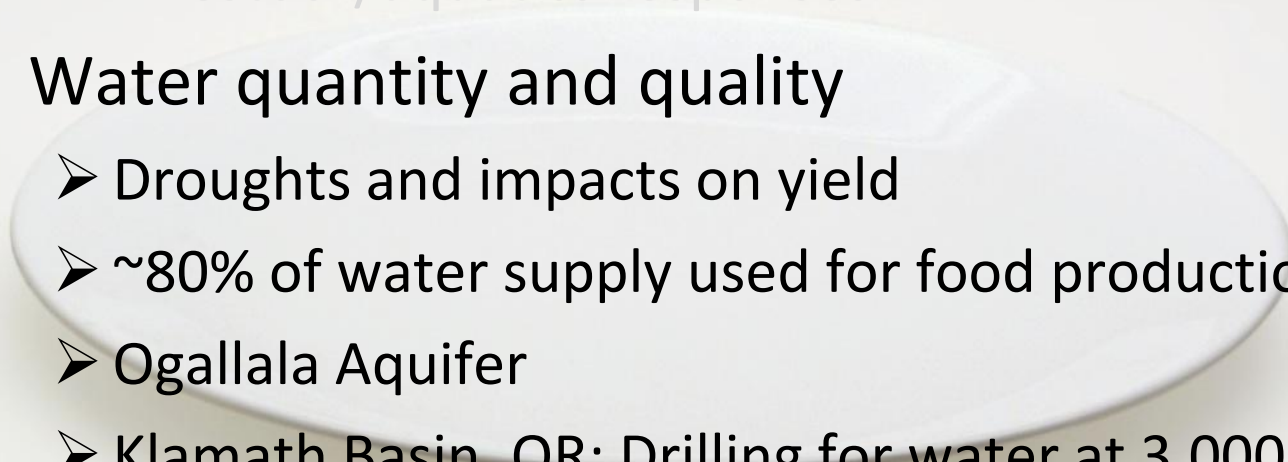
Fig 5.2

<http://www.climatechange-foodsecurity.org/ipcc.html>

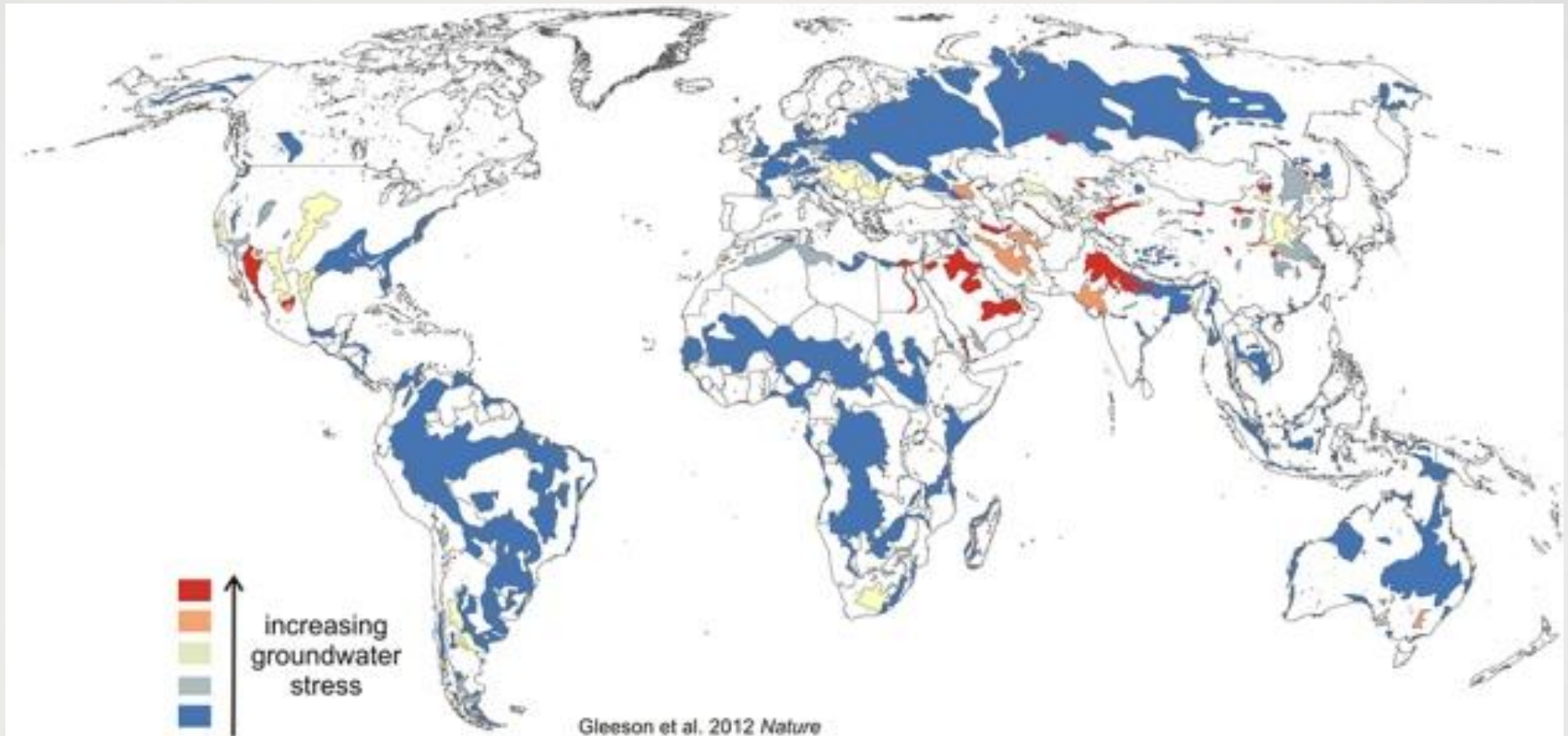
IPCC climate crop models AR4 4 2007 WG 2 Ch 4

Abiotic Constraints

- Soil depletion
- GHGs and Climate Change
- Correlation between yield and temperature
 - 4°C increase: crop failures, malnutrition
 - Livestock/aquatics responses
- **Water quantity and quality**
 - Droughts and impacts on yield
 - ~80% of water supply used for food production
 - Ogallala Aquifer
 - Klamath Basin, OR: Drilling for water at 3,000 ft



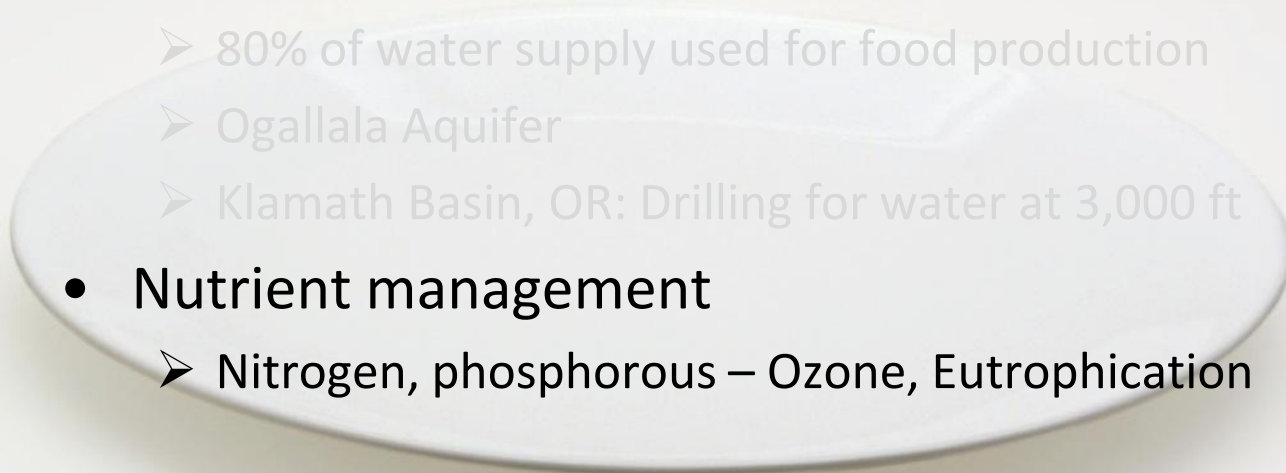
Aquifers under stress



GLEESON, T. ET AL., Nature, August 2012

Abiotic Constraints

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- **Nutrient management**
 - Nitrogen, phosphorous – Ozone, Eutrophication



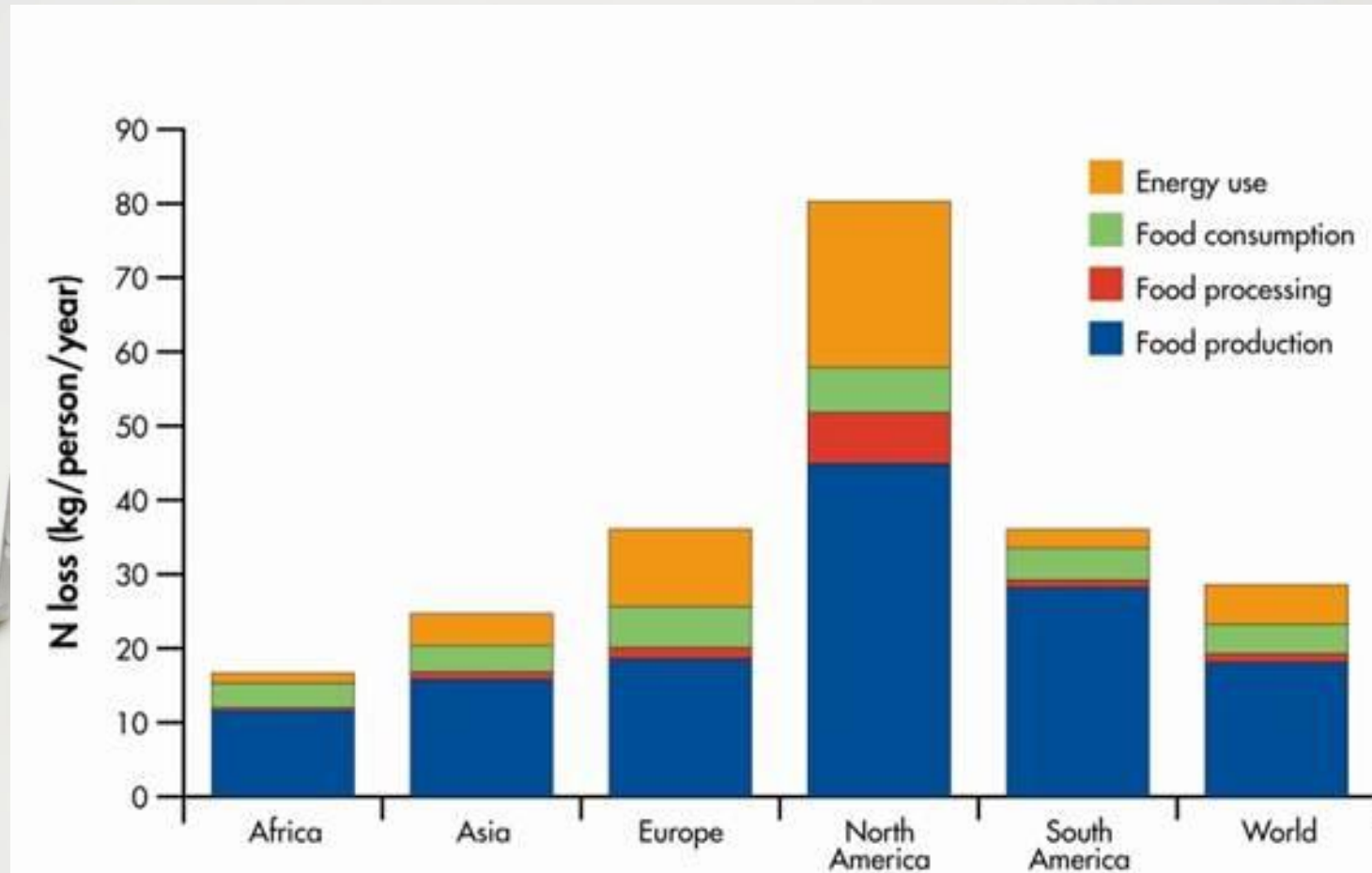


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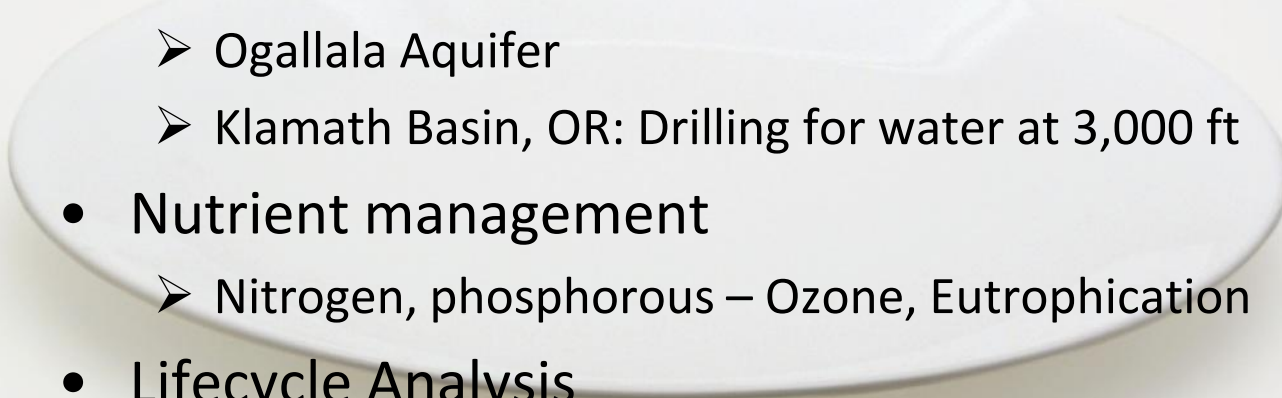
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Nitrogen Loss Indicator



Abiotic Constraints

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- Nutrient management
 - Nitrogen, phosphorous – Ozone, Eutrophication
- Lifecycle Analysis





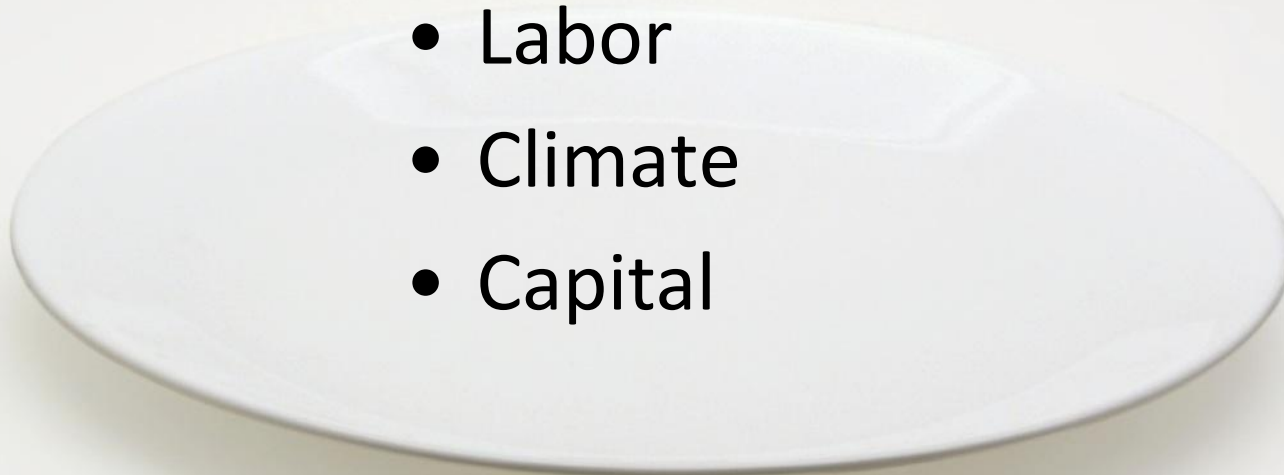
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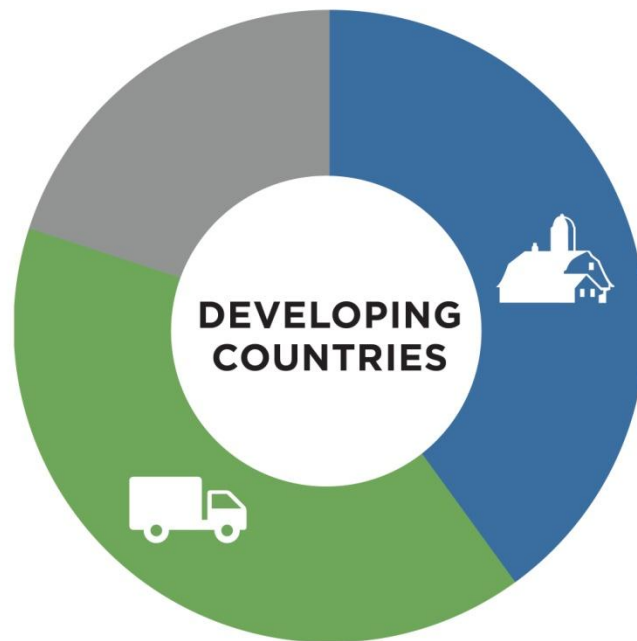
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Most Significant/Immediate Abiotic Constraints

- Arable land
- Water
- Labor
- Climate
- Capital



FOOD WASTE / FOOD LOSS



- Double food production in 40 years
- Cut loss/waste by half?
- Impact climate change

- On-Farm
- Transport & Processing
- Retail
- Food Service
- Home & Municipal
- Retail, Food Service, Home & Municipal (combined)

Farming systems

- Improved technologies
 - Productivity gap: 1.5 → 2%
 - Peak farmland – Ausubel et al. 2013
- Closed loop systems
- Cooperatives – Kibbutz?
- Integrated/diversified
- Smart farming
 - Robotics, sensors, sentinels
- Resilient intensification
 - Policies and consequences
- Vertical farming
- Hydroponics
- Aquaponics



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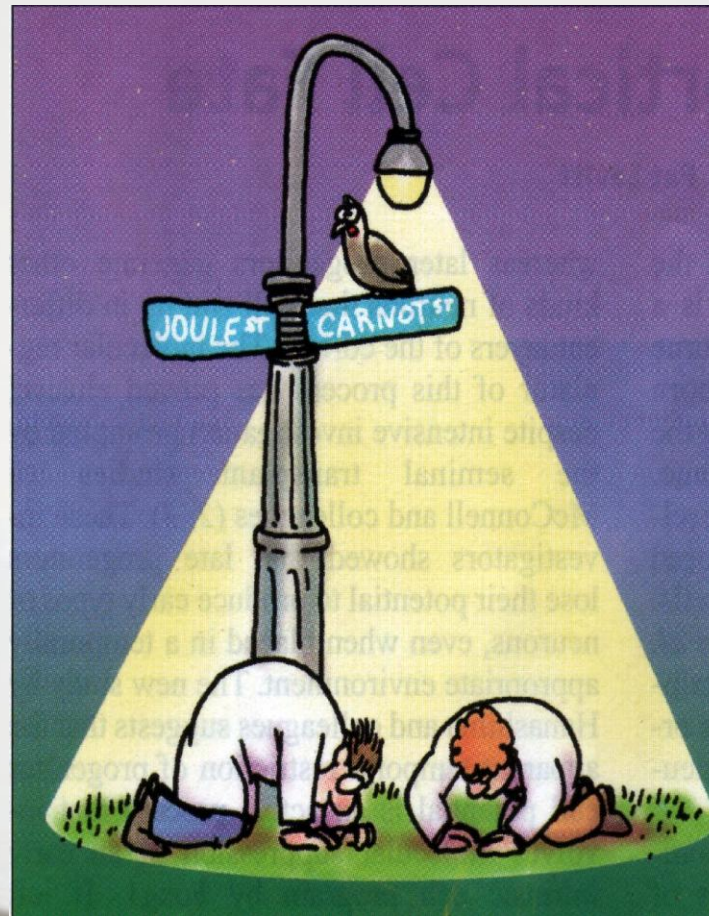
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Policies/Regulation/Marketing

- Governance
- Socially beneficial policies, programs
- Poverty reduction
- Education
- Trade – local to global
- Jobs
- Environmental degradation/conservation



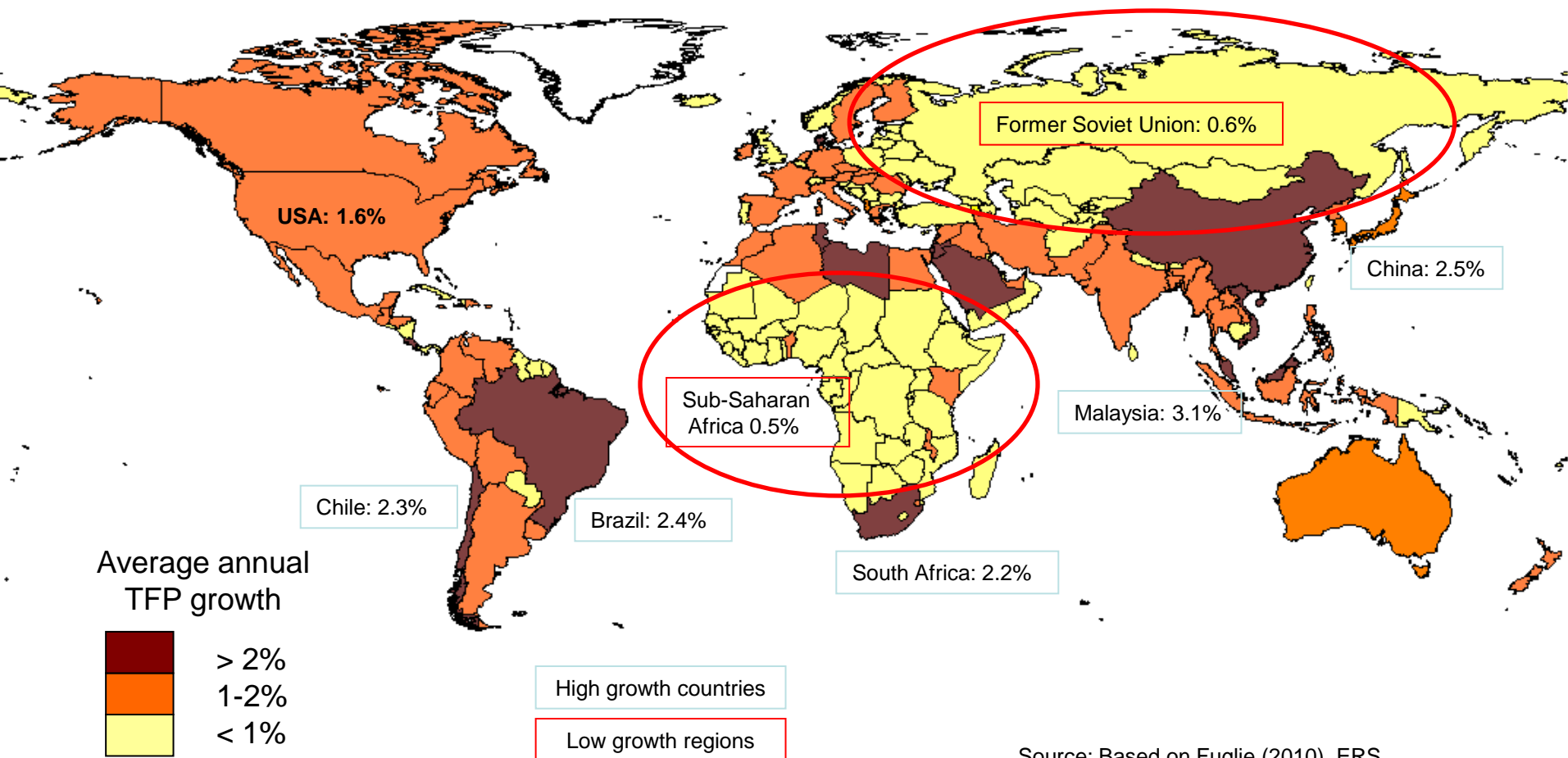
Path Forward: New Paradigms



Path Forward

- 
- A white ceramic plate is centered in the lower half of the slide. To the left of the plate is a silver fork, and to the right is a silver butter knife. The background is a light gray gradient.
- Virtual water and nitrogen
 - True costs?
 - Transformative approaches
 - Perennial/multi cropping
 - Conversion of deserts?
 - Algae in oceans?
 - Bio-/nano-technology
 - Modern Meadow
 - 3-D printing
 - Pest management
 - Education & Extension
 - Big data
 - Policy research
 - Partnerships
 - Governments
 - NGOs
 - Private
 - Academic
 - Research investments

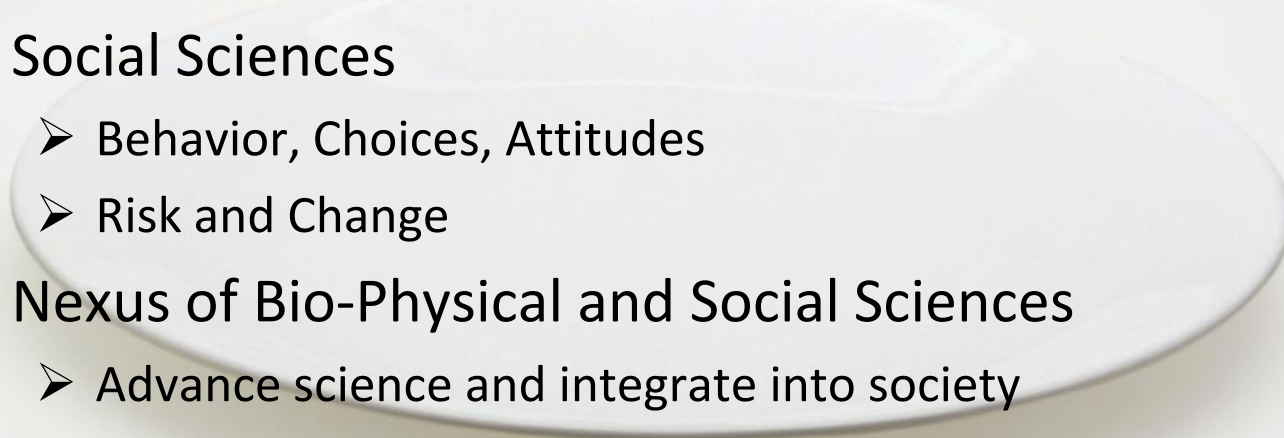
Agricultural TFP growth by country, 1970-2007



Source: Based on Fuglie (2010), ERS.

Humans Matter

- Consumers, businesses, groups, communities, towns, states and countries make decisions
 - Information-dependent: Haves and Havenots
- Acceptance of technologies
- People impacts
 - Technical, Policy, Regulatory, and Social Change
- Social Sciences
 - Behavior, Choices, Attitudes
 - Risk and Change
- Nexus of Bio-Physical and Social Sciences
 - Advance science and integrate into society



Path Forward

G20 Principles – Six Strategic Platforms

A white oval plate is centered on a light gray surface. Six colored squares are arranged in a 3x2 grid on the plate. To the left of the plate is a silver fork, and to the right is a silver butter knife. The squares are: top-left (blue) 'Open Access to Scholarly Publications', top-right (red) 'Open Access to Germplasm Collections', middle-left (black) 'Open Access to Genetic and Genomic Data', middle-right (green) 'Accelerated Technology Transfer', bottom-left (orange) 'Improved Statistics', and bottom-right (purple) 'Improved Extension'.

Open Access
to Scholarly
Publications

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Open Access
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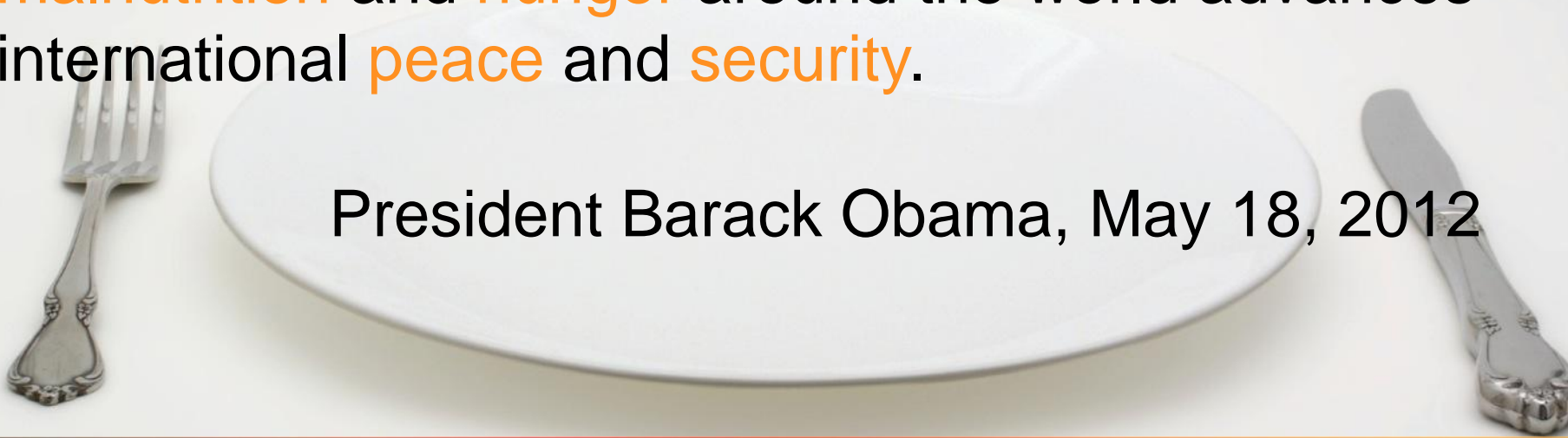
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We've seen how **spikes in food prices** can plunge millions into **poverty**, which in turn can cause **riots** that cost lives and can lead to **instability**. And this danger will only grow if a surging global **population** isn't matched by surging food **production**. So reducing **malnutrition** and **hunger** around the world advances international **peace** and **security**.

A white oval plate is centered in the lower half of the image. To the left of the plate is a silver fork, and to the right is a silver butter knife. The background is a light, neutral color.

President Barack Obama, May 18, 2012



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Current World Population 7,045,879, ~~200~~

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