Challenging Agriculture’s Long-Term Path

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10 billion people by 2050: Where will the additional people be born?

Population change between 2018 and 2050 by major region (millions)

- Africa: 1302
- Latin America, Caribbean: 134
- Northern America: 72
- Europe: -16
- Oceania: 23
- Asia: 717
Changing Nature of Demand
"Over the last week, rainfall totals in the region have been running at 400% to 600% above normal," according to the National Weather Service (May 29, 2019)

>1000 tornado reports (Jan-May, 2019)

"Corn prices jump to 3-year high amid extreme wet weather," by Emiko Terazono.
Climate Change leads to Temperature Extremes

Courtesy of Dr. John Ingram, Oxford University
Higher Mean Temperature Raises the Yield Variance
(Mid-Latitude Grain Production)
Climate change impacts on crop pathogens and pests

- Insect, weed and crop range shifts
- Reduced winter fallows
- Insect herbivory

Plant physiological status
Altered growth pathways
Weaker immune response
Altered abiotic response

Temperature

Plant physiological status
Normal growth pathways
Stronger immune response
Normal abiotic response

CO₂

Humidity

Pathogen status
Stronger pathogen survival
Stronger spore germination
Stronger virulence factor expression
Stronger virulence factor delivery

Weaker pathogen survival
Weaker spore germination
Weaker virulence factor expression
Weaker virulence factor delivery

Pathogen status

Plant resistance

Stronger

Weaker

Pathogen virulence

Weaker

Stronger

Disease

Health

Src: Velasquez et al Current Biology 2018
Policy-Induced Price Volatility

• Governments protect special interests (farmers, consumers, agro-industry)

• Global market volatility increases with simultaneous shocks in large trading countries

• Countries stabilize domestic prices, making world prices more volatile (e.g., ban on exports)

• High prices/spikes hurt consumers, risk of food riots

• Volatility creates uncertainty for producers, agro-industry
India is the world’s largest user of groundwater
Exceeds extraction of U.S. and China combined
90% used for agriculture (wheat, rice, sugar...)
Deep tube wells: 100,000 to 2.6 million over 30 years
Water and energy subsidies
How to keep the next generation of farmers in business?

• Alter cropping systems to meet long-term demands and climate/water constraints
• Breed for emerging stresses and new crops
• Rebuild soil organic matter
• Transform groundwater policy: incentivize water use efficiency; monitor at basin scale; set regional or basin-wide caps
• Re-think trade relationships, e.g., Africa, India
Thank You