Agricultural Risk Management*

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May 25, 2011

*At Local, Regional, and Global Scales

Climate Information for Managing Risks
University of Florida IFAS
Southeast Climate Consortium
May 25, 2011
Are ‘perfect storm’ conditions continuing . . .
Agricultural Risk Factors

- Poor harvests in major producing countries linked to extreme weather events
- Declining food stocks – world stocks were at their lowest in 2008 since the 1970s
- High oil and energy prices raising the cost of fertilizers, irrigation and transportation
- Lack of investment in the agricultural sector
- Subsidized production of bio-fuels that substitute for food production
- Speculative transactions, including large commercial traders hedging in futures markets and small traders hedging and building up storage
- Export restrictions
- Longer-term issues: land availability; yield plateaus; yield gaps; population growth; climate change
Update

Agricultural Risk Factors

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✓ Lack of investment in the agricultural sector
✓ Subsidized production of bio-fuels that substitute food production
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✓ Longer-term issues: land availability; yield plateaus; yield gaps; climate change; population growth
2010 Extreme Heat wave → Drought in Russia

• 2010 failure of the Ukrainian grain crop due to heatwave
• Russia froze wheat exports Aug. 15 2011 . . .

• Devastating drought in Niger during summer of 2010.
• Central US floods May, 2011

• Back-to-back 100-year floods in the Northern Great Plains during 2009 and 2010

• Recent floods in Australia

Extreme Precipitation → Flooding in Australia
Oil and Fertilizer Prices

EIA, 2011
Biofuels

Almost all of the increase in global maize production from 2004 to 2007 went to biofuels production (World Bank 2008).

In the United States, as much as one third of the maize crop goes to ethanol production, up from 5 percent a decade ago, and biofuel subsidies range between US$11-13 billion a year (IISD, 2007).

Increased biofuel demand in 2000-2007 is estimated to have contributed to ~30 percent of the weighted average increase of cereal prices.

*US biofuel subsidies still in place, may change as priorities change*
**Longer Term Issues**

**Land Availability & Yield Plateaus**

Cassman et al., 2011

Fig. 1. (a) Global land area used in cereal production. (b) Global trends in grain yield of the three major cereal crops.

Fig. 2. Grain yield trends of the three major cereals in selected countries. USA maize yields are means for the western Corn Belt and Great Plains states: CO, KS, NE, ND, OK, SD, TX, and WY.
Yield Gaps

In most major irrigated wheat, rice, and maize systems, yields appear to be at or near 80% of yield potential, with no evidence for yields having exceeded this threshold to date.

Average yields in rainfed systems are commonly 50% or less of yield potential, suggesting ample room for improvement, though estimation of yield gaps for rainfed regions is subject to more errors than for irrigated regions.

A fundamental constraint in these systems appears to be uncertainty in growing season weather; thus tools to address this uncertainty would likely reduce gaps.

Otherwise, short-term prospects for yield gains in irrigated agriculture appear grim without increased yield potential.

Reducing the gap between average and potential yields is critical.
• The two years differed by less than 0.018 degrees Fahrenheit.
• The difference is smaller than the uncertainty in comparing the temperatures of recent years, putting them into a statistical tie.
• In the new analysis, the next warmest years are 1998, 2002, 2003, 2006, 2007 and 2009, which are statistically tied for third warmest year.
• The analysis found 2010 approximately 1.13 °F warmer than the average global surface temperature from 1951 to 1980.
• The temperature trend, including data from 2010, shows the climate has warmed by approximately 0.36 °F per decade since the late 1970s.
• The analysis produced at GISS is compiled from weather data from more than 1000 meteorological stations around the world, satellite observations of sea surface temperature and Antarctic research station measurements.
• The record temperature in 2010 is particularly noteworthy, because the last half of the year was marked by a transition to strong La Niña conditions, which bring cool sea surface temperatures to the eastern tropical Pacific Ocean.
Efforts to anticipate how climate change will affect future food availability can benefit from understanding the impacts of changes to date.

Here we show that in the cropping regions and growing seasons of most countries, with the important exception of the United States, temperature trends for 1980-2008 exceeded one standard deviation of historic year-to-year variability.

Models that link yields of the four largest commodity crops to weather indicate that global maize and wheat production declined by 3.8% and 5.5%, respectively, compared to a counterfactual without climate trends.

For soybeans and rice, winners and losers largely balanced out. Climate trends were large enough in some countries to offset a significant portion of the increases in average yields that arose from technology, CO2 fertilization, and other factors.

**Fig. 3. Estimated net impact of climate trends for 1980-2008**
on crop yields for major producers and for global production. Values are expressed as percent of average yield. Gray bars show median estimate and error bars show 5-95% confidence interval from bootstrap resampling with 500 replicates. Red and blue dots show median estimate of impact for T trend and P trend, respectively.
Earlier Emergence of Insects

In a six-decade long study at a biological research station in Spain, increasing earlier time of first appearance for the honey bee, cabbage white butterfly, potato beetle and olive fly were found.

Gordon and Sanz, 2005; Gutierrez et al., 2010
Projected Yield Changes 2050s

Potential changes (%) in national cereal yields for the 2050s (compared with 1990) under the HadCM3 SRES A2a scenario with and without CO$_2$ effects (DSSAT)

Yield Effects with CO$_2$, rainfed wheat
CSIRO A1B (DSSAT)

Parry et al. -30% to +20%
IFPRI -25% to +25%
GAEZ -32% to +19%

GAEZ IIASA 2009 rain-fed cereals Hadley A2
North America -7 to -1%; Europe -4 to 3;
Central Asia 14-19%; Southern Africa -32 to -29

Schlenker & Lobel Africa multi GCMs
-22 to -2% statistical approach
Global Population Projections

Toward 10 Billion

New projections by the United Nations suggest the world’s population may surpass 10 billion by 2100 — with Asia and Africa far and away the most populous regions.

Source: United Nations
Managing Risks to the Global Agricultural System

Progressive Levels of Adaptation
Challenges and Opportunities

Benefit from adaptation vs. Climate change

- Increasing complexity, cost and risk
- Transformation from landuse or distribution change
- New products such as ecosystem services
- Production chain approaches
- Climate change-ready germplasm
- Diversification and risk management

- Varieties, planting times, spacing
- Stubble, water, nutrient and canopy management etc

Howden 2010
The Agricultural Model Intercomparison and Improvement Project (AgMIP)

Cynthia Rosenzweig, NASA Goddard Institute for Space Studies
Jim Jones, University of Florida
Jerry Hatfield, USDA Agricultural Research Service, Ames, IA
and the AgMIP Leadership Team

AgMIP Kick-off Workshop
October 28-30, 2010

Website, forum, and list-serve at http://www.agmip.org
AgMIP Elements and Linkages

- Historical Observations, CMIP3/5, Downscaling, and Weather Generation
- Crop Modeling Groups, Regional Agricultural Experts
- Agricultural Economic Modeling Groups, Regional Economists

Climate Scenarios

Crop Models

Agricultural Economic Models

Intercomparisons
- Improve Crop and Ag Econ Models
- Gauge Uncertainties
- Scenario Methods

Capacity Building
- Vulnerability Assessment
- Adaptation and Mitigation
- Trade Policy Instruments
- Technological Exchange

Extended Applications
- Water Resources
- Pests and Diseases
- Livestock and Pastures
- Land-use

Information Technologies
- Online Project Guidance, Archive, and Clearinghouse
Why AgMIP?

• Agricultural risks, food security and climate change
  – How will climate affect agriculture across major agricultural regions?
  – Many studies assume declining food prices
  – Recent food crises and extreme events question this assumption

• Consistent approach needed to enable agricultural sector analysis across relevant scales and disciplines
  – Great demand for assessment of model capabilities and uncertainties
  – Build transdisciplinary community

Based upon Rosenzweig and Parry, 1994
AgMIP Objectives

• Improve scientific and adaptive capacity of major agricultural regions in developing and developed world

• Collaborate with regional experts in agronomy, economics, and climate to build strong basis for applied simulations addressing key regional questions

• Develop framework to identify and prioritize regional adaptation strategies

• Incorporate crop and agricultural trade model improvements in coordinated assessment of future climate conditions

• Include multiple models, scenarios, locations, crops and participants to explore uncertainty and the impact of methodological choices

• Understand roles of land use and mitigation

• Link to key on-going efforts
  – CGIAR/ESSP, CCAFS, Global Futures, MOSAICC, IPCC AR5, others
Track 1: Model Inter-comparison and Improvement

Track 2: Coordinated Future Scenario Simulations

AgMIP Cross-Cutting Themes
Agricultural Pathways, Uncertainties, and Aggregation
AgMIP Products

- Model Intercomparison Protocols
- Representative Agricultural Pathways linked to IPCC SES
- Set of consistent climate/crop model inputs for economic models
- Consistent multi-model results for integrated estimates of climate change effects on agriculture and food security
- IT databases, interface
- Documented model improvements
- Research results on uncertainty, scaling, simulation of CO$_2$ effects, regional assessments, global assessment
- Framework for extensions to grazing/livestock, water, pests and diseases, etc.

Timing: Contributions to AR5 WGII

Continuing process
Next Steps for AgMIP

• Pilot Studies for crop modeling and climate scenarios
  – Wheat pilot
  – Pilot intercomparison of weather generator methodologies
  – CORDEX pilot for South African agriculture
  – IT case studies and pilot database tools

• Annual Regional Workshops and Global Workshop
  – Brazil (Campinas; Aug 1-5, 2011), North America, Europe, Sub-Saharan Africa, South Asia, China, Australia
  – Conduct simulations according to AgMIP protocols
  – Global Workshop just prior to ASA annual meeting (San Antonio, October 13-15, 2011)

• Economic Model Intercomparison and Improvement
  – Global agricultural economic models and Integrated Assessment Models
  – Following representative agricultural pathways
  – Utilizing AgMIP regional crop model results

• Fast-track Global Assessment for IPCC AR5
  – France pilot study for regional aggregation
  – Develop Representative Agricultural Pathways
  – Test uncertainty analysis methods
Agricultural Risk Management Conclusions 2008

• The world food crisis may be the harbinger of how climate change effects will be realized in agriculture, i.e., as one of multiple stresses (aka ‘the perfect storm’) that comes together to cause significant widespread problems.
• Rapid adoption of mitigation programs may bring unintended consequences. We must do better!
• Stationary is dead. Warming trends and trends in extremes are the new ‘normal.’
• Increasing production this year is critical: helping ag sector/farmers to use climate information more effectively is an urgent challenge right now.
• We still need to improve projections of long-term risk.
Agricultural Risk Management
Conclusions 2011

• The recurring world food crisis may be the harbinger of how climate change effects will be realized in agriculture, i.e., as one of multiple stresses (aka ‘the perfect storm’) that comes together to cause significant widespread problems.

• Rapid adoption of mitigation programs may bring unintended consequences. We must do better!

• Stationary is continues to be dead. Warming trends and trends in extremes are the new ‘normal.’

• Increasing production this year is critical: helping ag sector/farmers to use climate information more effectively is an urgent challenge right now. Still true!

• We still need to AgMIP is working to improve projections of long-term risk.
Goal is to entrain additional participants, regions, crops, and models in a continuing process

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