January 7, 2019

AGEC 528

Global Change and the Challenge of Sustainably Feeding a Growing Planet

(CRN 10441)

An interdisciplinary course at Purdue University

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KRAN 645, Office Hours Th 3 – 4:30/Fri: 1:30 – 3 pm

Department of Agricultural Economics

Spring Semester, 2019

Tuesday/Thursday: 10:30 – 11:45am, KRAN G-5

Background and Motivation

Effective functioning of the global food system is critical to human well-being on the planet – providing nutrition, employment, and an important source of income for hundreds of millions of people, including a majority of the world's poorest households. However, this same food system is transforming the earth system. These environmental stresses have recently been conceptualized as risks to the 'safe operating space' within the earth's planetary boundaries. Exceedances of these planetary boundaries represent potentially irreversible alterations of the earth system. Conversion of natural lands to farming and the loss of biodiversity, pollution from excess nutrient applications in agriculture, the depletion of groundwater stocks, and the emission of climate-altering greenhouse gases all pose significant risks to the planet. Balancing the critical role of the food system in feeding the world's growing population while respecting these planetary boundaries is one of the grand challenges faced by society today.

This class will explore the trade-offs and synergies arising out of these competing demands on the planets finite resources. We will do so within the context of an economic modeling framework that has proven amenable to integration of insights and knowledge from a variety of different disciplines, including agronomy, hydrology, biology, engineering, climate science, as well as a variety of social sciences. We will begin by exploring the drivers of change behind the evolution of the food system. We will then explore different dimensions of its interactions with the natural environment – focusing specifically on land, water, and natural ecosystem services. We will also explore how infringement on the planetary boundaries, as evidenced through water scarcity or climate change, for example, may alter the functioning of the food system.

Textbook **(e-book is free for Purdue Students via Purdue Libraries)**

Hertel, Thomas W. and U.L.C. Baldos, 2016. Global Change and the Challenge of Sustainably Feeding a Growing Planet, New York: Springer. http://link.springer.com/book/10.1007%2F978-3-319-22662-0

Format for the class

This is a 3-credit class, meeting twice a week for a full semester. The first meeting of each week will introduce a new dimension of global land use, food and environmental security. We will kick off the week's activities with a guest lecture, followed by student-led discussion of the week's readings. The second meeting of each week will emphasize the economics underpinning how this particular dimension of the problem affects the global food system, resource use, environmental quality and nutritional outcomes. This will be motivated by the lab assignments that students undertake. The lab assignments are based on the SIMPLE economic model of global agriculture (a Simplified International Model of agricultural Prices, Land use and the Environment). These assignments will allow students to obtain a hands-on assessment of the relative importance of the forces bearing on the long run supply and demand for food and land resources, key economic mechanisms mediating these adjustments, and the implications for food security and the environment. The capstone event in this course is the student project, which will involve the application of SIMPLE to a problem of the student's choosing. (See the final section of this syllabus for a listing of some of the previous topics pursued by students.)

The structure of each week's module will be as follows:

First meeting of each week *(10:30 am - 11:45 am: Tuesday; Krannert G-7)*

1) 45 minute presentation on the weekly topic led by a faculty member
2) 30 minute student-led discussion of the week's readings

Second meeting of each week *(10:30 am - 11:45 am: Thursday; Krannert G-7)*

1) 30 minute presentation on the economic dimensions of the topic
2) 45 minute discussion of the lab assignment and application to the week's topic

Prerequisites

This is an interdisciplinary course. As such, there are few prerequisites. A prior course in economics will ensure an understanding of the basic aspects of supply, demand and economic equilibrium. A solid grasp of mathematics up to and including differential calculus is also essential to understand the labs. Prior experience with mathematical modeling is also a plus.

Grading

Grades will be based on three factors: lab assignments, the quality of student led discussions of readings (students will be asked to submit two discussion questions in advance of Tuesday's lecture, each week, as well as leading one the discussion in one week), and the final project, which will be the focal point of the second half of the semester. There is no exam in this course.

Week 1: Overview: Planetary Boundaries and the Food System in the 21st Century
Jan. 8 - Lecture by Tom Hertel

During this week, we will obtain an overview of the factors governing the sustainability of the planet – particularly those relating to its land and water resources. We will also trace the long run evolution of agriculture and the challenges of sustainably feeding the world's growing population while respecting the planetary boundaries.

Required Readings:

Will Steffen, Katherine Richardson, Johan Rockstroem et al., (2015) "Planetary Boundaries: Guiding Human Development on a Changing Planet," *Science* 347(6223) DOI: 10.1126/science.1259855

Springmann, Marco, Michael Clark, Daniel Mason-D'Croz, Keith Wiebe, Benjamin Leon Bodirsky, Luis Lassaletta, Wim de Vries, et al. (2018) "Options for Keeping the Food System within Environmental Limits." *Nature* 562, no. 7728 (October): 519. https://doi.org/10.1038/s41586-018-0594-0

Text: Chapter 1: "Overview of Global Land Use, Food Security and the Environment"

Supplementary Reading:

Navin Ramankutty, Jonathan A Foley, and Nicholas J Olejniczak, "People on the Land: Changes in Global Population and Croplands during the 20th Century," *AMBIO: A Journal of the Human Environment* (2002): 251-257

Lab Discussion: *Introduction to the modelling software and overview on how to run and analyze the experiments using SIMPLE*

Week 2: Population growth and global food demand
Jan. 15 Guest Lecture by Brigitte Waldorf, Professor of Agricultural Economics

During this week, we will examine the impact of population and income growth on long run food demand. This debate traces its roots back to the classic publication by Thomas Malthus in 1798 in which he predicted that population would win the footrace between supply and demand for food. As population growth has slowed, the relative importance of dietary upgrading in this footrace has increased. These changes are largely driven by rising per capita incomes and the richer diets are much more land-intensive, hence putting additional pressure on the global resource base. When temporary scarcity arises, it is typically the low income households which experience significant reductions in food consumption in response to rising price. This response is important from the point of view of nutrition as well as the manner in which global supply and demand are balanced in the face of a limited resource base.

Required Readings:

Gerland, P., et al. “World population stabilization unlikely this century” *Science* 346, no. 6206: 234-237.

Kc, Samir, and Wolfgang Lutz. “The Human Core of the Shared Socioeconomic Pathways: Population Scenarios by Age, Sex and Level of Education for All Countries to 2100.” *Global Environmental Change: Human and Policy Dimensions* 42 (January 2017): 181–92. https://doi.org/10.1016/j.gloenvcha.2014.06.004 .

Textbook: Chapter 2: “Population and Income as Drivers of Global Change”

Supplementary Reading:

Lutz, W., W. Butz, S. KC, W. Sanderson and S. Scherbov. “9 billion or 11 billion: The research behind new population projections” http://blog.iiasa.ac.at/2014/09/23/9-billion-or-11-billion-the-research-behind-new-population-projections/ .

Clements, K. and J. Si, (2018). “Engel’s Law, Diet Diversity and the Quality of Food Consumption”, American Journal of Agricultural Economics 100(1):1-22.

Lab Assignment 1: *Simulate the impact on global and regional food demands in 2050 of varying assumptions about population growth and the income responsiveness of food demand.*

Week 3: Yield Growth and Yield Gaps
Jan. 22 Guest Lecture by Jeffrey Volenec, Professor of Agronomy, Purdue University

Over the past 50 years, three-quarters of agricultural output growth came from higher yields. Can this success story be repeated over the next 50 years? There are signs that yield growth is slowing significantly for some key crops. Is this due to underinvestment in technology? Or is it due to looming bio-physical limits on yield increases? We will consider these questions as well as examining why yields are still so low in much of the world, and what it might take to allow farmers to close these yield gaps.

Required Readings:

R.A. Fischer, Derek Byerlee, and G.O. Edmeades (2014), Chapters 1 and 14 in *Crop Yields and Global Food Security,* "ACIAR, Canberra, Australia.

David B. Lobell, Kenneth G. Cassman, and Christopher B. Field, "Crop Yield Gaps: Their Importance, Magnitudes, and Causes," *Annual Review of Environment and Resources* 34, no. 1 (11, 2009): 179-204;

Textbook: Chapter 3: Sections 3.1-3.2: "Productivity Growth and Yields in the Global Crops Sector"

Lab Discussion: *Examine the combined impact of population growth, income growth and biofuels on global land use in the context of supply response.*

Week 4: Total Factor Productivity Growth in the Agricultural System, January 29 - Lecture by Uris Baldos, Research Assistant Professor, Department of Agricultural Economics

Crop yield is a partial measure of productivity as it only reflects growth in output per unit of land input. Yields can rise due to improvements in technology – or simply due to increased use of fertilizers and other non-land inputs. To assess the overall changes in productivity in the agricultural sector, economists rely on total factor productivity (TFP) which takes into account all inputs used in agricultural production. During this week, we will explore the historical trends in agricultural TFP growth, its drivers, how changes in TFP affect consumers and producers and the implications of TFP growth for cropland use.

Required Readings:
Julian M. Alston, Jason M. Beddow, and Philip G. Pardey, "Agricultural Research, Productivity, and Food Prices in the Long Run," *Science* 325, no. 5945 (September 4, 2009): 1209-1210.

Keith Fuglie, "R&D Capital, R&D Spillovers, and Productivity Growth in World Agriculture," *Applied Economic Perspectives and Policy*, accessed November 22, 2017, https://doi.org/10.1093/aepp/ppx045.

Baldos, Uris, and Thomas Hertel. 2018. "Productivity Growth Is Key to Achieving Long Run Agricultural Sustainability." *Purdue Policy Research Institute, Policy Brief* 4 (1). https://docs.lib.purdue.edu/gpripb/ .

Textbook: Chapter 3: Sections 3.3-3.4: "Productivity Growth and Yields in the Global Crops Sector"

Lab Discussion: *Illustrating the key role of TFP growth and how this interacts with endogenous intensification to determined yield growth over time.*

Lab Assignment 2: *Simulate the impact of International Energy Agency projections of biofuels growth to 2035 under varying assumptions about the price responsiveness of the extensive and demand margins of economic behavior.*

Week 5: Supply response: Potential for Cropland expansion February 5: Lecture by Jing Liu, Research Economist, Purdue University

Absent sufficiently rapid yield growth, expansion at the extensive margin is inevitable. Many authors have asked the question: How much land is available for cropland expansion? And how productive is this land? If it is available, why is it not presently farmed? How responsive are producers' area expansion decisions to economic signals? What are the environmental consequences of expanding cropland area?

Required Readings:

Lambin, Eric. 2013. "Global Land Availability: Malthus vs. Ricardo". *Global Food Security* (in press).

Jonah Busch and Kalifi Ferretti-Gallon, "What Drives Deforestation and What Stops It? A Meta-Analysis," *Review of Environmental Economics and Policy* 11, no. 1 (January 1, 2017): 3–23, https://doi.org/10.1093/reep/rew013

Textbook: Chapter 4: "Economic Response to Scarcity"

Supplementary Reading:

Textbook Appendix B: "Analytical Framework: A Theoretical Model of Long Run Demand and Supply for Agricultural Land"

Emiliano Magrini, Jean Balié, and Cristian Morales-Opazo, "Price Signals and Supply Responses for Staple Food Crops in Sub-Saharan Africa," *Applied Economic Perspectives and Policy* 40, no. 2 (June 1, 2018): 276–96, https://doi.org/10.1093/aepp/ppx037

Villoria, N., D. Byerlee and J.R. Stevenson. (2014). "The Effects of Agricultural Technological Progress on Deforestation: What Do We Really Know?" *Applied Economic Perspectives and Policy*, doi: 10.1093/aepp/ppu005.

Lab Discussion: *Examine the combined impact of population growth, income growth and biofuels on cropland expansion around the world and the interactions between the intensive and extensive margins of supply response.*

Lab Assignment 3: *Examine the impact of climate change on crop productivity, global land use and agricultural prices.*

Week 6: Water Availability: Constraints and Opportunities
Feb. 12: Guest Lecture by Laura Bowling, Professor of Agronomy and Agricultural and Biological Engineering

Presently two-fifths of global crop production comes from irrigated areas that, when combined, account for just one-fifth of total cropland. This is a reflection of the very high productivity of irrigated agriculture. However, this irrigation activity accounts for 70% of freshwater withdrawals, and projections indicate that 50% of global river basins will be experiencing severe shortages by 2030. This will inevitably translate into water scarcity and ultimately to reductions in the water available for farming. Thus, water will be an increasingly key limiting factor for agricultural production in the coming decades.

Required Readings:

Jacob Burke and Karen Villholth, "Groundwater: a global assessment of scale and significance," in *Water for Food, Water for Life*, ed. David Molden (London and Colombo: Earthscan and International Water Management Institute, 2007), 395-423;

Laura C. Bowling and Keith A. Cherkauer (2018). "The Green, Blue and Gray Water Rainbow", Chapter 2 in *How to Feed the World*, J. Eise and K. Foster (eds.), Washington: Island Press.

Textbook: Chapter 5: "Water, Food and Environmental Security"

Lab Discussion: *Analyzing the global impacts of constraints on irrigated agricultural production.*

Week 7: Globalization, and the scope for feeding the world sustainably in 2050
February 19 – Lecture by Uris Baldos

Global drivers are increasingly driving local sustainability stresses, and responses to those stresses feed back to the global level. However, the extent of these interactions depends critically on international trade and the degree of global market integration. In this week, we will explore these themes, emphasizing the role of globalization in driving local outcomes as well as the consequences of policies put in place to improve food and environmental security.

Required Readings:
Eric Lambin and Partick Meyfroidt, "Global land use change, economic globalization and the looming land scarcity", *Proceedings of the National Academy of Sciences,* www.pnas.org/cgi/doi/10.1073/pnas.1100480108

Hertel, T.W. and U.L.C. Baldos. (2016) "Attaining Food and Environmental Security in an Era of Globalization", *Global Environmental Change*, 41:195-205.

Haqiqi, Iman, Laura Bowling, Sadia Jame, Thomas Hertel, Uris Baldos, and Jing Liu. 2018. "Global Drivers of Land and Water Sustainability Stresses at Mid-Century." *Purdue Policy Research Institute, Policy Brief* 4 (1). https://docs.lib.purdue.edu/gpripb/ .

Text: Chapter 11: "Global Change and the Food System in 2050"

Lab Discussion: *Examine the consequences of market segmentation for the effectiveness of sustainability policies.*

Lab Assignment 4: *Examine the consequences of market segmentation for the effectiveness of sustainability policies.*

Week 8: Consumer Preferences for Food: Implications for Sustainability
February 26 – Guest Lecture by Jayson Lusk, Distinguished Professor & Department Head, Agricultural Economics

Up to this point, we have focused on heavily on the supply side of the global sustainability challenge. In this week, we will consider the role of consumer preferences and food policies in shaping the global agricultural landscape and the potential for achieving a more sustainable future.

Required Readings:
Lusk, J. (2017). "Evaluating Policy Proposals of the Food Movement", *Applied Economic Perspectives and Policy*, Volume 39, Issue 3, 1 September 2017, Pages 387–406, https://doi.org/10.1093/aepp/ppx035

Lusk, J. (2013). Lunch with Pigou: Externalities and the "Hidden" Cost of Food. *Agricultural and Resource Economics Review, 42*(3), 419-435. doi:10.1017/S1068280500004913

Supplementary Reading:
Okrent, A. and J. Alston (2012). "The Effects of Farm Commodity and Food Retail Policies on Obesity and Economic Welfare in the United States", *American Journal of Agricultural Economics*, 94(3):611-646.

Lab Discussion: *Analysis of the impact of reducing food waste on global food and environmental security.*

Lab Assignment 5: *Examine the nutritional implications associated with alternative long run economic scenarios. Also discuss class projects.*

Week 9: Nutrition and Food Security
March 5 - Guest Lecture by Gerald Shively, Professor of Agricultural Economics

Nutrition and food security are closely linked to developments in the agricultural sector particularly in low-income regions. Given this, the impacts of climate change on agriculture will affect the nutritional outcomes at the household level. In this week, we examine the key measures used in quantifying hunger and malnutrition and how these metrics are affected by climate change and by the long run drivers of the global food and farm system.

Required Readings:

Black, R.E., L.H. Allen, Z.A. Bhutta, L.E. Caulfield, M. de Onis, M. Ezzati, C. Mathers and J. Rivera. (2008). “Maternal and Child Under-nutrition: Global and Regional Exposure and Health Consequences”, *Lancet* (371):243-260.

Behrens, P. et al. (2017). “Evaluating the Environmental Impacts of Dietary Recommendations”. *PNAS* 114(51):13412-13417.

Textbook: Chapter 10: “Food Security and Nutrition”

Supplementary Reading:

Gerald E. Shively, “Infrastructure Mitigates the Sensitivity of Child Growth to Local Agriculture and Rainfall in Nepal and Uganda,” *Proceedings of the National Academy of Sciences* 114, no. 5 (January 31, 2017): 903–8, https://doi.org/10.1073/pnas.1524482114

Baldos, U. L. C., & Hertel, T. W. (2014). Global food security in 2050: the role of agricultural productivity and climate change. Australian Journal of Agricultural and Resource Economics, 58(4), 554-570

Lab Discussion: *The evolution of global and regional undernutrition under alternative future scenarios.*

SPRING BREAK

Week 10: Post-Harvest Losses
March 19 – Guest Lecture by Larry Murdock, Distinguished Professor Emeritus, Department of Entomology

Goal 12.3 of the United Nations’ Sustainable Development Goals aims to cut in half the global food waste and post-harvest losses by 2030. How large are these losses? What are the barriers to achieving this goal? The global food system is extremely diverse, so we will focus attention this week on on-farm, post-harvest storage losses in Sub-Saharan Africa. The Purdue Improved Crop Storage (PICS) Project has developed technologies that have been widely recognized as being valuable in lowering losses. But there remain important barriers to widespread adoption and we will explore these issues and the potential impacts of reducing post-harvest losses on food and environmental security.

Required Readings:

Kaminski, Jonathan, and Luc Christiaensen. 2014. “Post-Harvest Loss in Sub-Saharan Africa—what Do Farmers Say?” *Global Food Security*, SI: GFS Conference 2013, 3 (3–4): 149–58. doi:10.1016/j.gfs.2014.10.002

L. L. Murdock and I. B. Baoua, “On Purdue Improved Cowpea Storage (PICS) Technology: Background, Mode of Action, Future Prospects,” *Journal of Stored Products Research*, Hermetic Storage of Grain in Developing Nations, 58 (July 2014): 3–11, https://doi.org/10.1016/j.jspr.2014.02.006

Supplementary Reading:

FAO, “Global Food Losses and Food Waste: Extent, Causes and Prevention” (Rome, Italy, 2011).

Alexander, Peter et al. (2016). “Losses, inefficiencies and waste in the global food system”, *Agricultural Systems* 153(2017:190-200.

Lab Discussion: *Evaluate the impact of reducing post-harvest food losses in Africa.*

Start working on class project: schedule one-on-one meeting with Prof. Hertel

Week 11: Understanding the Linkages between Biodiversity and Agricultural Production
March 26: Guest Lecture by Prof. Ralf Seppelt, Head, Department of Computational Landscape Ecology, Helmholtz-Centre for Environmental Research, Leipzig

There are many dimensions of biodiversity. Here, we will focus on those that affect agricultural production and sustainability. This is often termed ‘natural capital’ and it can play an important role stimulating agricultural output (e.g., natural pollinators) or aiding in achieving sustainability goals (e.g., sequestering carbon and reducing GHG emissions).

Required Readings:

L.A. Garibaldi et al., “Wild Pollinators Enhance Fruit Set of Crops Regardless of Honey Bee Abundance”, *Science*, 339, 1608(2013); DOI: 10.1126/science.1230200

Seppelt, R., Beckmann, M., Ceauşu, S., Cord, A. F., Gerstner, K., Gurevitch, J., Newbold, T. (2016). Harmonizing Biodiversity Conservation and Productivity in the Context of Increasing Demands on Landscapes. *BioScience*, *66*(10), 890–896. https://doi.org/10.1093/biosci/biw004

Text: Chapter 7, Sections 7.1, 7.3, 7.4: “Land-based Environmental Services”

Supplementary Reading:

T.H. Ricketts and E. Lonsdorf, (2013) “Mapping the Margin: Comparing Marginal Values of Tropical Forest Remnants for Pollination Services”, *Ecological Applications* 23(5):1113-1123.

Lab Discussion: *Analysis of the impacts of pollinator losses on sustainability of the food system.* ***Continue work on class projects***

Week 12: Environmental Impacts of Agriculture: Water Quality
April 2 – Guest Lecture by Professor Jane Frankenberger, Department of Agricultural and Biological Engineering

Excess nutrient runoff from agricultural lands is arguably the most important environmental impact of farming in the Corn Belt. Nitrogen and Phosphorous loading has not only polluted groundwater in the region, it has increased the cost of municipal water treatment and resulted in a massive dead zone in the Gulf of Mexico. This had led to calls by the National Hypoxia Task Force to reduce nitrate leaching by 45% in the Mississippi Basin. In light of ongoing pressures to increase food production, this presents a massive challenge. Fortunately, there are potential solutions to this problem involving improved in-field practices designed to increase nitrogen use efficiency, crop rotations which can reduce run-off, as well as edge of field practices such as managed drainage and wetland restoration which have the potential to reduce nutrients ending up in streams and rivers. During this week we will explore the nature of these challenges and how these site-specific measures might feedback to regional, national and global markets.

Required Readings:

Turner, R. E. & Rabalais, N. N. (1991). Changes in Mississippi River Water Quality this Century: Implications for coastal food webs. *BioScience* 41, 140–147.

Diaz, R. J. & Rosenberg, R. (2008). Spreading Dead Zones and Consequences for Marine Ecosystems. *Science* 321, 926–929.

Donner, S. D. & Kucharik, C. J. (2008). Corn-based ethanol production compromises goal of reducing nitrogen export by the Mississippi River. *PNAS*, 105, 4513–4518 (2008).

Supplementary Readings:

Liu, Jing, Thomas Hertel, Laura Bowling, Sadia Jame, Christopher Kucharik, and Navin Ramankutty. 2018. "Evaluating Alternative Options for Managing Nitrogen Losses from Corn Production." *Purdue Policy Research Institute, Policy Brief* 4 (3). https://docs.lib.purdue.edu/gpripb/ .

Lab Discussion: *Examine the potential for policy interventions to mitigate excess nutrient runoff from agriculture in the US Corn Belt and explore the consequences of these policies for regional and global markets.* ***Continue working on class project.***

Week 13: Environmental Impacts of Agriculture: Greenhouse Gases and Land-Based Climate Mitigation Policies
April 9 - Lecture by Tom Hertel

Most land management policies aimed at curbing GHG emissions and mitigating the effects of climate change are directed toward restoring and preserving natural forests. However, these policies will have unintended consequences for the availability of farmlands in the future. Some studies also point out the potential for GHG mitigation in the agricultural sector by reverting current croplands to natural land cover. During this week, we will explore the potential for these policies to mitigate GHG emissions and the effect of these land-based climate mitigation policies on global crop production and food prices.

Required Readings:

Griscom et al. (2017). “Natural Climate Solutions”. *Proceedings of the National Academy of Sciences*.

Golub, A.A., B.B. Henderson, T.W Hertel, P. Gerber, S.K. Rose and B. Sohngen (2012). “Global Climate Policy Impacts on Livestock, Land Use, Livelihoods and Food Security”, *Proceedings of the National Academy of Sciences*.

Text: Chapter 7, Sections 7.2, 7.5: “Land-based Environmental Services”

Supplementary Readings:

Busch, J. and K. Ferreti-Gallon (2017). “What Drives Deforestation and What Stops it?” Review of Environmental Economics and Policy, 11(1):3-23.

Brent Sohngen, “An Analysis of Forestry Carbon Sequestration as a Response to Climate Change” (*Copenhagen Consensus on Climate*, 2010)

Lab Discussion: *Examine the impact of land use change on GHG emissions. Explore exogenous shifts in the supply of land to agriculture in response to climate mitigation policies.* ***Continue working on class project***

Week 14: Climate Change as a factor influencing global agriculture April 16 - Guest lecture by Matt Huber, Professor of Earth and Atmospheric Sciences

The question of meeting global food, fiber and fuel demands in 2050 is greatly complicated by the prospect of climate change which is likely to alter temperature and precipitation as well as the frequency and intensity of extreme events. How will climate change affect land use? This will depend not only on the absolute impacts, but also on the relative impacts – the changes in comparative advantage of competing land using activities across regions of the world.

Required Readings:

Lobell, D., W. Schlenker and J. Costa-Roberts, 2011. “Climate Trends and Global Crop Production since 1980”, *Science*, 333(6042):616-620.

Schlenker, W. and M. Roberts, 2009. “Nonlinear temperature effects indicate severe damages to US crop yields under climate change”, *Proceedings of the National Academy of Sciences*, 106:37: 15594-15598.

Textbook: Chapter 6: “Climate Change Impacts in Agriculture”

Week 15: Presentation of Class Projects, April 23 and 25

Each individual will briefly present highlights from their class project, with time for Q&A with the rest of the class. A full write-up, in the form of a short research paper, will be submitted at the end of the semester. A menu of project ideas from previous years follows.

Ideas for Class Projects

(These are based on past class projects. We expect that many more ideas will emerge from our discussions during class):

1. ***Food Waste and Post-Harvest Losses:*** The UN-FAO estimates that one-third of global food production is lost or wasted so that only two-thirds of production is actually consumed. What are the implications of such losses for crop prices? How would a reduction in post-harvest losses affect nutritional outcomes?
2. ***Changing Nutrition Guidelines:*** The USDA is in the process of formulating a new set of nutrition guidelines. For the first time they are considering adding environmental impacts to these guidelines. How would such considerations change the pattern of food consumption? How would changing consumption patterns alter the pattern of global land use and GHG emissions?
3. ***Regulating non-point source pollution from agriculture:*** Arguably the most important environmental problem surrounding agricultural production in the Midwestern United States if the run-off of excess nutrients into streams, rivers and coastal ecosystems. The resulting incidence of hypoxic 'dead zones' has led to calls to greatly restrict nutrient use in agriculture as well as investing in conservation policies. How will such regulations affect production, prices and food security? Which are the most effective policies?
4. ***Empowerment of Women: Implications for Global Food Security:*** Women comprise a large share of the agricultural labor force and female-headed farms represent a large share of agricultural enterprises worldwide. Women are also key decision makers when it comes to household nutrition and fertility. As such, they are in a unique position to influence local, regional and global food security outcomes. However, lack of education and limited access to credit and other inputs currently limit the impact which women can have on these outcomes. How would greater empowerment of women change the global food security landscape?
5. ***Migration and Global Food Security:*** The migration of individuals across national borders is a global phenomenon which is currently on the rise. It affects for the supply of, and the demand for, food. What is the net impact on global food security of trends in international migration?
6. ***Virtual Trade in Water:*** Scientists have recently identified 'virtual trade in water' as an important element of the global sustainability puzzle. Virtual water exports arise when one country exports water intensive goods to another country. The water embodied in the production of this commodity for export is termed 'virtual water' and recent studies have documented the extent of such 'trade'. In light of the trends in population, income, productivity and biofuels alter virtual water trade between the present day and 2050?
7. **Constraints in irrigated agriculture**: Almost 40% of the world crop production is coming from irrigated lands. However, growing scarcity of water threatens to limit the potential of irrigated agricultural production to feed the world. Excessive water withdrawals also threaten to increase soil salinity and soil productivity. What are the potential impacts of constraints in irrigated agriculture on the global farm and food system.
8. ***Africa as the Sleeping Giant of Agriculture:*** In 2009, the World Bank published a report suggesting that the Guinea Savannah Zone of Africa could become the next breadbasket for the world. What would be the implications of such a development?
9. ***Urbanization:*** In one of our lab discussions, we explored urbanization's impacts on demand for land. However, one could dig deeper by looking at the quality of land that is being displaced. What are the implications for global land use, food security and the environment.

10. ***REDD:*** Similar to **Urbanization**, students could explore the impact of efforts to dedicate additional land to the production of environmental services. This would be implemented through adjustments to the regional conversion factors of land in environmental services to cropland.
11. ***Climate change:*** We also explored in our lab discussions the impacts of different types of climate shocks on agricultural productivity and land use. A deeper dive might entail converting existing studies of the impacts of climate change into shocks or parameter adjustments within our own model and exploring the results. Lab four discusses the parameters that could be adjusted to implement this idea.
12. ***Jevon's paradox:*** The Angelsen reading discusses Jevon's paradox - a situation in which yield growth might lead to extensification. A deeper exploration of the conditions under which we might expect such a result would be interesting. What is the demand elasticity required to generate this outcome? How do yield differentials across regions affect the likelihood of this outcome? Can these results tell us anything about the probability of experiencing Jevon's paradox in the real world?
13. ***Impacts of shifting population and income on global demand elasticity:*** Regional differences in demographics and income growth will shift the balance of global demand. How do these shifts change the aggregate global demand elasticity? How does this compare to shifting demand elasticities within regions? What impact does this have in moderating/amplifying the extensification impacts of biofuels mandates?
14. ***Biophysical/economic interaction:*** Relative yields (local yields versus the global maximum) might be indicative of how close a particular region is to the biophysical limits of intensification given current technologies. To understand how such biophysical limits interact with the economics governing the crop market, we might want to consider a linear relationship between relative yields and our intensification parameter. By plotting different regions on this linear relationship, one could determine whether such a biophysical limit, through its impact on the economic parameters, changes the outcomes of crop expansion scenarios.
15. ***Impacts of different types of technology growth:*** In our model, we can simulate land augmenting, land dis-augmenting and technology neutral productivity growth (through afland, afnland or both simultaneously). What are the realistic ranges of these types of productivity growth going forward? If yield growth outpaces non-land technology growth, what would be the impact on prices and extensification? Under different scenarios, does the clear relationship between land prices and extensification begin to break down?
16. ***Globalization:*** We have spent relatively little time in the labs relating global processes to local outcomes. However, it can be shown analytically that the *effective* elasticity of demand for a local market depends on the rest of the world's supply elasticity, the local production's share of the global market as well as the global demand elasticity. Among other possibilities, an analysis of globalization's impact might compare the extensification impacts of productivity changes in small markets (share of world supply is small) to large markets.
17. ***Changing productivity of livestock and food processing:*** We've spent a fair amount of time evaluating the impacts of changing agricultural productivity. However, one could also assess the implications of changes in the TFP of livestock production or food processing. Contradictory effects of these downstream productivity changes (less crops required to produce a good, but demand is now increasing) may lead to interesting results depending on the assumed parameter values.
18. ***Market mediated responses:*** Hertel (2011) highlights the importance of considering economic factors when estimating the land use implications of changes in biofuels demand. A similar analysis could assess to what scale biophysical estimates of the

impacts of demand shocks (e.g. population growth, income expansion) are moderated through economic processes such as intensification and demand reduction.

19. ***Cost-benefit analysis of productivity growth:*** Several papers provide estimates of the cost and scale of historical TFP growth. Using these estimates, one could estimate the consumer surplus generated by the yield growth to evaluate the cost effectiveness. Similarly, estimates of the cost per hectare saved would be possible for land-sparing technologies.