# GEOG 19.01: Climate Change and the Future of Agriculture


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**X-Hours:** Expected use as detailed in syllabus and for makeup classes
**Web:** https://canvas.dartmouth.edu

## Course Description

The global agricultural sector faces the significant challenge of feeding a population projected to increase to 9 billion by mid-century under an evolving climate. This course will explore the physical geography of agricultural production systems throughout the world with an emphasis on the interactions between crops, climate, water, soils, and technology.

Lectures are designed to be interactive and will encourage participation through questions, discussion, and in-class exercises. Problem sets will include data analysis and the use of a simple crop model in MATLAB, which will be introduced and is available in Rahr Lab. This course counts as a Natural and Physical Science without Lab (SCI) Distributive Course Requirement.

## Learning Objectives

By the end of this course, students will be able to:

1. Describe plant physiology, the global agricultural system, and key constraints to crop production in regions throughout the world.
2. Identify the mechanisms of, and distinguish between, climate variability and anthropogenic climate change.
3. Understand the basics of data manipulation and computer programming.
4. Outline the impacts of climate change on agriculture at local to global scales.
5. Interpret and apply scientific literature.
6. Analyze modeled and observed climate and crop data.
7. Assess the implications of current and expected future physical agricultural systems on global hunger.
8. Evaluate potential strategies for improving global crop production within the context of a changing climate.

## Prerequisites

None

## Textbook

Sheaffer, C. C., and K. M. Moncada, 2012: *Introduction to Agronomy: Food, Crops, and Environment*. Cengage Learning, 720 pp.

## Course Resources on Reserve or Available Online

Diamond, J., 1987: The worst mistake in the history of the human race. *Discover*, **8**, 64–66.

FAO, 2009: *How to Feed the World 2050*. http://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf.

Fedoroff, N., and Coauthors, 2010: Radically rethinking agriculture for the 21st century. *Science*, **327**, 833–834.
Hillel, D., and C. Rosenzweig, eds., 2010: *Handbook of Climate Change and Agroecosystems: Impacts, Adaptation, and Mitigation*. World Scientific, 440 pp.
——, and ——, eds., 2012: *Handbook of Climate Change and Agroecosystems: Global and Regional Aspects and Implications*. World Scientific, 330 pp.
IPCC, 2013: *Summary for Policymakers, in: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. T. Stocker et al., Eds. 33 pp.
Lobell, D. B., W. Schlenker, and J. Costa-Roberts, 2011: Climate trends and global crop production since 1980. *Science*, **333**, 616–620.
Marston, B., 2013: *The Science of Climate Change*. http://vimeo.com/77243727.
Mueller, N. D., J. S. Gerber, M. Johnston, D. K. Ray, N. Ramankutty, and J. A. Foley, 2012: Closing yield gaps through nutrient and water management. *Nature*, **490**, 254–257.
Niggli, U., H. Schmid, and A. Fliessbach, 2008: Organic farming and climate change. http://orgprints.org/13414/3/niggli-etal-2008-itc-climate-change.pdf.
Piao, S., and Coauthors, 2010: The impacts of climate change on water resources and agriculture in China. *Nature*, **467**, 43–51.
Pollan, M., 2006: *The Omnivore's Dilemma: A Natural History of Four Meals*. Penguin, 464 pp.
Sheaffer, C. C., and K. M. Moncada, 2012: *Introduction to Agronomy: Food, Crops, and Environment*. Cengage Learning, 720 pp.
Tilman, D., C. Balzer, J. Hill, and B. L. Befort, 2011: Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, **108**, 20260–20264.
USGCRP, 2014: *Climate Change Impacts in the United States*. J.M. Melillo, T.T. Richmond, and G. Yohe, Eds. 841 pp.

**Grading**

Problem sets will contain a mix of data analysis, back-of-envelope calculations, and short answer questions. Problem sets must be uploaded as one document in doc, docx, or pdf format via Canvas on or before the date and time due. Assignments received after that are considered late. Late assignments will be penalized 10% per 24-hour period. In-class exercises will not be collected or graded, but will cover important concepts likely to appear on both problem sets and exams. Exams will contain a mix of definitions, multiple choice, true/false, data/figure analysis, simple back-of-envelope calculations, short answer questions, and long answer questions. Exam #1 will include material from classes up to the Exam #1 Review. Exam #2 will be cumulative, but weighted toward material not tested in Exam #1. No makeup exams will be given without prior consent or documented emergency. Class participation will be assessed primarily on reading reactions with some consideration of student engagement. Reading reactions consist of a brief summary of the reading, as well as a mix of questions, key insights, and critiques submitted via Canvas online text entry in advance of class. Reactions will be graded on a 1-3 scale.

| Assignment | Weighting |
|---|---|
| Problem Set #1 | 15% |
| Problem Set #2 | 15% |
| Problem Set #3 | 15% |
| Exam #1 | 25% |
| Exam #2 | 25% |
| Class Participation | 5% |

**Student Needs**

Students requesting disability-related accommodations and services for this course are encouraged to contact me as early in the term as possible. In order for accommodations to be authorized, students are required to consult with Student Accessibility Services (SAS; student.accessibility.services@dartmouth.edu; SAS website; 603-646-9900) and to email me their SAS accommodation form. We will then work together with SAS if accommodations need to be modified based on the online learning environment. If students have questions about whether they are eligible for accommodations, they should contact the SAS office. All inquiries and discussions will remain confidential.

**Academic Honesty**

All students must comply with Dartmouth's Academic Honor Principle, described here: https://students.dartmouth.edu/judicial-affairs/policy/academic-honor-principle, with additional guidance here: https://writing-speech.dartmouth.edu/learning/materials/sources-and-citations-dartmouth. If you have questions or concerns, please contact me or the Undergraduate Deans Office.

**Mental Health**

The academic environment at Dartmouth is challenging, terms are intensive, and classes are not the only demanding part of your life. There are resources available on campus to support your wellness, including your Undergraduate Dean (http://www.dartmouth.edu/~upperde/), Counseling and Human Development (http://www.dartmouth.edu/~chd/), and the Student Wellness Center (http://www.dartmouth.edu/~healthed/).

**Religious Observances**

If you have a religious observance that conflicts with your participation in this course, please meet with me before the end of the second week of the term to discuss appropriate accommodations.

**Textbook Costs and Financial Difficulty**

If you encounter financial challenges related to this class, please let me know.

**Schedule**

| Date | Topic | Assignments and Readings |
|---|---|---|
| Class 1 | Climate Change and Agriculture<br>TEDX: The Other Inconvenient Truth | |
| Class 2 | Discussion - Agriculture or Hunting and Gathering? | Diamond 1987; Sheaffer and Moncada 2012, Chapter 1 |

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| Class 3 | The Global Agricultural Landscape | FAO 2009; Sheaffer and Moncada 2012, Chapter 3 |
| Class 4 | Introduction to MATLAB | |
| Class 5 | Crops: Amaranth to Zucchini | Sheaffer and Moncada 2012, Chapter 4 |
| Class 6 | MATLAB Working Session | |
| Class 7 | Plant Physiology | Sheaffer and Moncada 2012, Chapter 8 |
| Class 8 | Corn Nitrogen Experiment Setup | |
| Class 9 | Crops and Environment | Sheaffer and Moncada 2012, Chapter 10; Problem Set #1 Due |
| Class 10 | Industrial and Subsistence Farming: Closing the Yield Gap | Sheaffer and Moncada 2012, Chapter 10; Mueller et al. 2012 |
| Class 11 | Exam #1 Review | |
| Class 12 | Climate Change Mechanisms and Processes | Marston 2013 |
| Class 13 | Exam #1 | |
| Class 14 | Climate Change Mechanisms and Processes | Marston 2013 |
| Class 15 | The IPCC and Paris! | IPCC 2013 |
| Class 16 | MATLAB Working Session | |
| Class 17 | Agriculture under Climate Change: Carbon Dioxide and Nitrogen | (Hillel and Rosenzweig 2010), Chapter 5 |
| Class 18 | Discussion - Agriculture under Climate Change: Temperature and Precipitation | Lobell et al. 2011 |
| Class 19 | Discussion: Agriculture under Climate Change: Water | Piao et al. 2010 |
| Class 20 | Agriculture under Climate Change: Adaptation and Mitigation | Hillel and Rosenzweig 2012, Chapter 2; Problem Set #2 Due |
| Class 21 | Agriculture under Climate Change: Adaptation and Mitigation | |
| Class 22 | Climate Change and Agriculture: The United States | USGCRP 2014, Chapters 2 and 6 |
| Class 23 | MATLAB Working Session | |
| Class 24 | Climate Change and Agriculture: Regional Perspectives | Hillel and Rosenzweig 2012, Chapter 6 |
| Class 25 | Discussion - Organic Farms, the Omnivore's Dilemma, and Joel Salatin | Pollan 2006, Chapter 9; Niggli et al. 2008 |

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| Class 26 | Non-traditional Farming Techniques | Fedoroff et al. 2010 |
| Class 27 | Current Research in Agriculture and Climate Change | Hillel and Rosenzweig 2012, Chapter 14; Problem Set #3 Due |
| Class 28 | Exam #2 Review | |
| Class 29 | Discussion - Let's Fix Global Agriculture | Hillel and Rosenzweig 2012, Conclusion; Tilman et al. 2011 |
| Class 30 | Exam #2 | |