Feeding the Poorest Billion:
Food Security in the 21st Century

Developed by
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Unit Introduction

Feeding the Poorest Billion: Food Security in the 21st Century

Rationale and Introduction to Lessons

Between July 2007 and July 2008, international prices for corn, wheat, and other staple food products skyrocketed to never-before-seen levels. A flurry of media coverage delivered blame in shares to speculators, hoarders, and the burgeoning biofuel industry. As economists scrambled to untangle the true causes of the price spike, consumers struggled to accommodate the sudden increase in their grocery bills, and farmers hurried to adjust planting, growing, and harvesting strategies to maximize their windfall profits.

The 2008 food price crisis—and subsequent price spikes in 2011—brought new attention to our global food system and to the myriad forces with which it interacts. At a basic biological level, food is critical to human life, and the quantity and quality of the food that we consume determines our health, happiness, and productivity. But the production, distribution, and consumption of food are complicated processes, driven not only by social norms and personal tastes but also by both short and long-term trends in technology, economics, and global climate.

At any time, any of these trends may threaten an individual's access to an adequate supply of high-quality food—that is, the individual's food security. The Food and Agriculture Organization of the United Nations defines food security as a state that exists "when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Despite decades of progress in agricultural technology, economic development, and poverty relief, food security continues to elude hundreds of millions of people around the world.

Although hunger and poverty receive ongoing attention in both academics and politics, there is now a need for a new, interdisciplinary understanding of the forces that impede and facilitate global access to food. This unit examines the issue of food security from multiple angles—from the physical science of agricultural production, to the biology of food consumption and utilization, to the economics of food prices, poverty, and international development. The goal is to give students a complete appreciation for the factors that determine food security status, and to foster creative, multidisciplinary thinking about our efforts to ensure global food security in the 21st century.

Lesson One, *Poverty, Hunger, and Food Security*, introduces students to food security as a basic concept. Students learn how food security is related to poverty and hunger, and explore how governments and aid agencies use measures of poverty and hunger to track food security around the world. Throughout the lesson, students are encouraged to think broadly and creatively about the food security impact of various environmental, economic, political, and social factors.

Lesson Two, *Food Production*, explores trends in physical availability of food as determined by local and global agricultural productivity. Students learn about common measures of agricultural productivity, and use these measures to compare productivity between crops, regions, and time periods. At the end of the lesson, students learn about the "Green Revolution"—a series of major developments in agricultural technology and policy that dramatically increased crop productivity in the latter half of the twentieth century. The lesson activities highlight connections between global agricultural productivity and hunger and poverty in the developing world, and encourage students to recognize both the positive and negative food security impacts of productivity-enhancing technologies.

Lesson Three, *Agriculture and Health*, focuses on connections between agriculture and human health. The lesson begins with a summary of major issues such as quantity and quality of food consumption, environmental health, and worker safety. Students complete an in-class study of micronutrients—their importance for human health, and their connections to agriculture through the production of animal products and produce crops—and an independent case study focused on the manifestations of agriculture-health links in a particular developing country. The lesson includes a card game that illustrates the challenges of meeting calorie and micronutrient needs on a limited food budget.

Lesson Four, Part One, *Food Price Dynamics*, focuses on one of several factors that govern economic access to food: local and global trends in food prices. Students explore key fundamentals of food price dynamics, including principles of supply and demand; price correlations by commodity and region; the interaction between retail, wholesale, and producer prices; and the food security implications of the "food price dilemma." The lesson introduces new economic vocabulary and includes brainstorming, graph analysis, news analysis, and group discussion activities.

Lesson Four, Part Two, *Poverty*, focuses on the characteristics and causes of, and potential antidotes to, rural poverty in the developing world. Students begin by exploring how features of poverty, such as duration and depth, differ between developed and developing countries. Armed with new definitions that accurately describe these differences, students move on to investigate causes of ultrapoverty and chronic poverty, focusing on the role of productive assets in a rural poverty cycle. The lesson concludes with a group project that invites students to develop their own anti-poverty strategies. Throughout the lesson, students examine poverty from both a quantitative perspective, through data and graphs, and from a qualitative perspective, through stories and case studies.

Lesson Four, Part Three, *Agriculture in the National Economy*, introduces a new linkage between agricultural productivity and food security: higher agricultural productivity raises rural incomes and reduces the share of the workforce engaged in farming, leading to the growth of new, higher-value industries that increase economic prosperity—and reduce poverty—at the national level. Students learn common macroeconomic terms used to describe the structure, function, and productivity of national and regional economies, complete data activities that explore the linkages between macroeconomic variables and food security, and work in groups to complete a case study of national development paths in four different countries.

Lesson Five, *Trade*, explores the food security effects of both commercial and noncommercial exchange of food between nations. Students investigate regional and time trends in commercial agricultural trade, and consider a range of factors that may affect the impact of trade on global food security. The lesson also covers trends and issues related to global food aid, including donors and recipients, sourcing and distribution strategies, and factors that determine the effectiveness of various food aid strategies in combating hunger and poverty.

Lesson Six, Part One, *Biofuels*, introduces one emerging challenge to global food security: the use of food crops in the production of biofuels. The lesson opens with an introductory reading that defines a biofuel, summarizes reasons for rising interest in biofuels, and presents advantages and disadvantages of replacing fossil fuels with biofuels. Students learn about trends in biofuel production and consumption, and consider the pros and cons of biofuel development. By quantifying the social and environmental effects of converting corn to ethanol, and by conducting detailed research on a range of biofuel feedstocks, students prepare to respond to an important question in modern food and energy security debates: Should we be converting food crops to fuel?

Lesson Six, Part Two, *Climate and Agriculture*, explores interactions between food security and global climate, focusing on projected 21st-century climate change and its effects on food security. The lesson draws on selections from a lecture by Stanford University professor David Lobell, whose work focuses on the effects of climate on agriculture. Lobell's lecture outlines expected 21st-century climate trends in the context of current limits on the accuracy of scientific forecasts, explains the effects of temperature and precipitation affect crop productivity, and explore various strategies for minimizing the food security impacts of future climate change. The lesson concludes with a writing exercise that asks students to weigh the pros and cons of these strategies, and to select a particular set of strategies to support and defend.

Unit Goals

Students will be able to

- explain the concept of food security, differentiating between food security, hunger, and poverty;
- describe geographic and historical trends in food security and food production;

- explain how food, agriculture, and food security interact with both social systems (e.g., economic trends, global trade relationships) and physical systems (e.g., the human body, local soil conditions, and global climate);
- recognize connections between food security and current events, and identify emerging challenges to food security;
- describe ongoing strategies to improve food security, and develop and defend their own strategies;
- interpret and synthesize information from a variety of sources, including news articles, policy briefs, academic lectures and papers, and data and graphs;
- use a broad vocabulary of terms related to food security, agriculture, economics, and international development;
- conduct efficient Internet research, recognizing and citing reliable sources; and
- work effectively in groups.

Connections to Curriculum Standards

This unit has been designed to meet certain U.S. national education standards in science, economics, and social studies. Specific standards are listed below, accompanied by notes on the unit lessons that incorporate relevant content.

1. Science standards defined by the National Research Council's 1996 *National Science Education Standards*:

Standard F: Science in Personal and Social Perspectives

As a result of activities in grades 9–12, all students should develop understanding of:

- Personal and community health (Lesson Three, *Agriculture and Health*)
- Population growth
- Natural resources (Lesson Two, *Food Production*)
- Environmental quality (Lesson Two, *Food Production*; Lesson Three, *Agriculture and Health*)
- Natural and human-induced hazards (Lesson Three, *Agriculture and Health*; Lesson Six, Part Two, *Climate and Agriculture*)
- Science and technology in local, national, and global challenges (Lesson Two, *Food Production*; Lesson Six, Part One, *Biofuels*)

2. Economics standards defined by the Council for Economic Education's 2010 *Voluntary National Content Standards in Economics (2nd Ed.)*:

Standard 5: Trade, and Standard 6: Specialization

Voluntary exchange occurs only when all participating parties expect to gain. This is true for trade among individuals or organizations within a nation, and among individuals or organizations in different nations. When individuals, regions, and nations specialize in what they can produce at the lowest cost and then trade with others, both production and consumption increase.

(Lesson Five, *Trade*)

Standard 7: Markets and Prices, and Standard 8: Role of Prices

A market exists when buyers and sellers interact. This interaction determines market prices and thereby allocates scarce goods and services. Prices send signals and provide incentives to buyers and sellers. When supply or demand changes, market prices adjust, affecting incentives.

(Lesson Four, Part One, *Food Price Dynamics*)

Standard 15: Economic Growth

Investment in factories, machinery, new technology, and in the health, education, and training of people stimulates economic growth and can raise future standards of living.

(Lesson Four, Part Two, *Poverty,* and Lesson Four, Part Three, *Agriculture in the National Economy*)

3. Social studies standards defined by the National Council for the Social Studies' 2010 *National Curriculum Standards for Social Studies*:

Standard III: People, Places, and Environments

Social studies programs should include experiences that provide for the study *of people, places, and environments*, so that the learner can:

(f) describe and speculate about physical system changes, such as seasons, climate and weather, and the water cycle (Lesson Six, Part Two, *Climate and Agriculture*)

(h) examine the interaction of human beings and their physical environment, the use of land, building of cities, and ecosystem changes in selected locales and regions (Lesson Two, *Food Production*)

(j) observe and speculate about social and economic effects of environmental changes and crises resulting from phenomena such as floods, storms, and drought (Lesson Two, *Food Production,* and Lesson Six, Part Two, *Climate and Agriculture*)

(k) consider existing uses and propose and evaluate alternative uses of resources and land in home, school, community, the region, and beyond (Lesson Two, *Food Production,* and Lesson Six, Part One, *Biofuels*)

Standard VII: Production, Distribution, and Consumption

Social studies programs should include experiences that provide for the study of *how people organize for the production, distribution, and consumption of goods and services*, so that the learner can:

(e) describe how we depend upon workers with specialized jobs and the ways in which they contribute to the production and exchange of goods and services (Lesson Four, Part Three, *Agriculture in the National Economy,* and Lesson Five, *Trade*)

(g) describe the relationship of price to supply and demand (Lesson Four, Part One, *Food Price Dynamics*)

(i) use economic concepts such as supply demand, and price to help explain events in the community and nation (Lesson Four, Part One, *Food Price Dynamics*)

(j) apply knowledge of economic concepts in developing a response to a current local economic issue (Lesson Four, Part Two, *Poverty*)

Standard VIII: Science, Technology, and Society

Social studies programs should include experiences that provide for the study of *relationships among science, technology, and society*, so that learners can:

(a) identify and describe examples in which science and technology have changed the lives of people (Lesson Two, *Food Production*)

(b) identify and describe examples in which science and technology have led to changes in the physical environment (Lesson Two, *Food Production*)

(e) suggest ways to monitor science and technology in order to protect the physical environmental, individual rights, and the common good (Lesson Two, *Food Production*, and Lesson Six, Part One, *Biofuels*)

Standard IX: Global Connections

Social studies programs should include experiences that provide for the study of *global connections and independence*, so that the learner can:

(c) examine the effects of changing technologies on the global community (Lesson Two, *Food Production*, and Lesson Six, Part One, *Biofuels*)

(d) explore causes, consequences, and possible solutions to persistent, contemporary, and emerging global issues (all lessons)

4. Common Core Standards for English Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects, 2010 (published by the National Governors Association Center for Best Practices and the Council of Chief State School Officers, Washington D.C.)

Reading, writing, and data analysis exercises throughout the unit are relevant to the following Common Core Standards:

Reading Standards for Literacy in History/Social Studies 6–12

Grades 11–12 students:

1. Cite specific textual evidence to support analysis of primary and secondary sources, connecting insights gained from specific details to an understanding of the text as a whole.
2. Determine the central ideas or information of a primary or secondary source; provide an accurate summary that makes clear the relationships among the key details and ideas.
7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6–12

Grades 11–12 students:

1. Write arguments focused on *discipline-specific* content.
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

Materials

Handouts and materials on CD-ROM/DVD have been provided for each lesson. Permission is given to reproduce these materials for classroom use only. Each lesson provides a list of materials necessary for that lesson. Note that certain supplementary materials are available online through the SPICE website.

The enclosed DVD contains video footage of all lecture clips referenced in the unit. Full-length footage of each lecture is available online through the Stanford Center for Food Security and the Environment, at http://foodsecurity.stanford.edu/events/series/global_food_policy_series. Teachers may play the lecture clips from the DVD using a computer or DVD player, or use an Internet-ready computer and projector to access lecture clips (and any additional footage) online.

Projections used in the unit are provided in hard copy with the materials for each lesson. Teachers have the choice to copy the projections to transparency paper for display on an overhead projector, or to scan them for projection through a computer projector.

Equipment

The equipment list below is comprehensive for the entire unit; note that not all lessons require every equipment item in this list. Consult the lesson procedures for specific requirements for each lesson.

- Overhead projector or computer projector (for displaying projections)
- DVD player or Internet-ready computer with projector (for playing lecture clips)
- Internet-ready computers for student use (for Internet research)
- Poster boards for group projects
- Whiteboard or blackboard

Time and Suggested Sequence of Activities

Feeding the Poorest Billion is divided into seven lessons, with some lessons having multiple parts, and the last lesson being a collection of suggested final projects. Each lesson or lesson part is designed to take between one and four 50-minute class periods. The unit has been designed with flexibility in mind; it is not expected that all classes using the unit will complete every full-length lesson. General suggestions for selecting and sequencing lessons within the unit are provided below. Instructors may wish to consult the "Curriculum Standards" section for additional guidance when selecting lessons to meet particular state or national content standards. Each lesson also includes an "Extensions and Excerpts" section, which outlines suggestions for instructors who would like to spend more, or less, time on the lesson topic.

Note: It is recommended that all classes using the unit complete Lesson One, *Poverty, Hunger, and Food Security,* for an introduction to the topic of food security and to key vocabulary used throughout the unit. However, instructors may find it sufficient to familiarize themselves with the Lesson One content and/or to ask students to complete a selection of the handouts and activities, in class or as homework. Instructors may select one or more of the activities in Lesson Seven, *Suggested Concluding Activities,* to conclude any sequence of lessons. Note that the expectations for some of the concluding activities may need to be modified if students have not completed the entire unit.

1. **Food Production**
   The following sequence of lessons focuses on food production. Content includes physical science (e.g., nutrients required for crop growth, effects of heat and drought on crops, etc.) as well as social science (e.g., historical trends in agricultural productivity, social effects of productivity improvements, etc.)
   - Lesson One, *Poverty, Hunger, and Food Security*
   - Lesson Two, *Food Production*
   - Lesson Six, Part Two, *Climate and Agriculture*
2. **Food Utilization**
   The following sequence of lessons focuses on food utilization by individuals (i.e., the role of micronutrients in food quality and health) and communities (focusing on the conflict between biofuel production and human food consumption).
   - Lesson One, *Poverty, Hunger, and Food Security*
   - Lesson Three, *Agriculture and Health*

- Lesson Six, Part One, *Biofuels*

3. **Food Economics**
   The following sequence of lessons focuses on the economics of global food security. Students will learn how food prices, poverty, macroeconomic development, and trade interact to influence food security status. Note: Lesson Four, Part Three may be omitted if students have little or no prior exposure to topics in economics; this lesson contains advanced material.
   - Lesson One, *Poverty, Hunger, and Food Security*
   - Lesson Four, Part One, *Food Price Dynamics*
   - Lesson Four, Part Two, *Poverty*
   - Lesson Four, Part Three, *Agriculture in the National Economy*
   - Lesson Five, *Trade*
4. **Current Events**
   The following sequence of lessons focuses on three major challenges to food security that received significant media attention during the first decade of the 21st century.
   - Lesson One, *Poverty, Hunger, and Food Security*
   - Lesson Four, *Part One, Food Price Dynamics*
   - Lesson Six, Part One, *Biofuels*
   - Lesson Six, Part Two, *Climate and Agriculture*
5. **Standalone Lessons**
   Although any lesson in the unit may be taught as a standalone lesson, the following lessons are particularly appropriate for a short foray into food security topics. Lesson One is recommended, but not required, as a prerequisite for the other lessons in this list.
   - Lesson One, *Poverty, Hunger, and Food Security*
   - Lesson Two, *Food Production*
   - Lesson Three, *Agriculture and Health*
   - Lesson Six, Part One, *Biofuels*
   - Lesson Six, Part Two, *Climate and Agriculture*

Subjects and Suggested Grade Levels

This curriculum unit is recommended for use in the following secondary school classes:

- Contemporary World Issues
- Economics
- Health
- Social Studies

The unit materials will be most appropriate for advanced high school students, i.e., grades 11–12 and AP students.

Related SPICE Units

If you find this curriculum unit valuable, the following SPICE lessons and units may also be relevant to your classes. For more information on these and other units, please visit the SPICE website at http://spice.stanford.edu.

10,000 Shovels: China's Urbanization and Economic Development

An Introduction to Aquaculture: The Pros and Cons of Fish Production

Feeding a Hungry World: Focus on Rice in Asia and the Pacific

International Environmental Politics

Living in a Global Age: A Simulation of International Trade

SPICE Resources Online

SPICE offers free resources online, such as documentaries, interactive teaching materials, and excerpts from various SPICE units. To learn more about these resources or to join the SPICE mailing list, please visit the "resources" section of the SPICE website at http://spice.stanford.edu.

Lesson One

Poverty, Hunger, and Food Security

Organizing Questions

- What does it mean to be poor, hungry, or food insecure?
- How is food insecurity related to hunger and poverty?
- How have global rates of poverty and hunger changed over time?
- Where are the poor and hungry concentrated today?
- What environmental, demographic, political, and economic factors affect food security?

Introduction

This lesson introduces students to food security as a basic concept. Students learn how food security is related to poverty and hunger, and explore how governments and aid agencies use measures of poverty and hunger to track food security around the world. Throughout the lesson, students are encouraged to think broadly and creatively about the impact of various environmental, economic, political, and social factors on food security.

Objectives

In this lesson, students will

- explore concepts and definitions of food security, and appreciate the multidimensionality of food security issues;
- learn how and why poverty and hunger are formally measured and tracked;
- recognize spatial and temporal variation in poverty and hunger rates; and
- think broadly and creatively about environmental, economic, political, and social factors that affect food security, setting the stage for deeper exploration of these factors in the remainder of the unit.

Materials

- Handout 1A, *Definition Guide: Food Security*
- Handout 1B, *Definition Guide: Hunger*
- Handout 1C, *Definition Guide: Poverty*
- Handout 2, *Introduction to Basic Food Security Concepts*
- Handout 3, *Reading Guide: Introduction to Basic Food Security Concepts*
- Handout 4, *Measuring Poverty and Hunger*
- Handout 5, *Poverty and Hunger Data Activity*
- Handout 6, *Quiz*
- Handout 7, *Exploring Food Security Factors*
- Handout 8, *Group Presentation Notes*

- Projection 1, *FAO Food Security Definition*
- Projection 2, *Poverty and Hunger Trends*
- Answer Key, *Reading Guide: Introduction to Basic Food Security Concepts*
- Answer Key, *Measuring Poverty and Hunger*
- Answer Key, *Poverty and Hunger Data Activity*
- Answer Key, *Quiz*

Equipment

- Whiteboard or chalkboard
- Projector (for displaying projections on Day One and Day Three)
- Five or six medium poster boards (for student displays on Day Four)
- Internet-ready computers (for student research on Day One and Day Three)

Teacher Preparation

1. Review all handouts, and make the correct number of copies (one per student, unless otherwise indicated).
2. Review the projections, and copy or scan them for display on a projector.
3. Prior to Day One and Day Three, arrange for Internet-ready computer access.
4. Prior to Day Four, arrange the room for group work.
5. Optional: Instructors may wish to consult the following sources for additional background information on hunger, poverty, and food security, and in preparation for evaluating student work on the Definition Guides and Food Security Factors exercise:
   - The UN Food and Agriculture Organization's hunger portal (http://www.fao.org/hunger/en)
   - The World Bank's Poverty home page and the World Bank's "Countries" page (both accessible through http://www.worldbank.org)
   - The UN Millennium Development Goals home page (www.un.org/millenniumgoals/) and the Goal Monitor (www.mdgmonitor.org)

Time

The complete lesson requires at least four 50 minute class periods.

Day One

1. (five minutes): Distribute one copy of Handout 1A, *Definition Guide: Food Security*, to each student. Explain that students will spend the period exploring this term. Give students about five minutes to write their own working definition of the term in the space provided on the handout.
2. (five minutes): Ask for volunteers to share their definitions with the class. Record students' main points on a chalkboard or whiteboard; encourage students to explain how they arrived at their own definitions and to offer thoughtful comments on others' definitions.

3. (15 minutes): Display Projection 1, *FAO Food Security Definition*, on an overhead projector. Ask students to copy the definition in the space provided on their handout, and to work with a neighbor to complete the following tasks:
   - Based on the FAO definition of food security, write a definition of food insecurity in their own words, and record this definition in the space provided on the handout.
   - Discuss the two questions on the projection, and write their answers in the space provided on the handout.
   - Use the space provided on the handout to brainstorm key features/questions about food security.
4. (20–25 minutes) Explain that students will spend the remainder of the period exploring two familiar terms that are closely related to food security: poverty and hunger. Distribute one copy each of Handouts 1B and 1C, *Definition Guide: Hunger* and *Definition Guide: Poverty*, to each student. Direct students to Internet-ready computers, and give students the remainder of the period to complete the handouts in pairs.
5. At the end of the period, distribute one copy each of Handout 2, *Introduction to Basic Food Security Concepts,* and Handout 3, *Reading Guide: Introduction to Basic Food Security Concepts,* to each student. Assign students the following homework:
   - Review the handout and complete the reading guide.
   - Complete the three definition guides if they did not do so in class.

Day Two

1. (10 minutes) Ask students to take out Handouts 2 and 3. Spend the first 10 minutes of class reviewing and discussing the answers to the reading guide questions as a class. Focus on the following questions to review and extend the material on the handout:
   - What is the relationship between poverty, hunger, and food security?
   - What is the distinction between food availability and food access? (This is a subtle point, and one that students should grasp early in the lesson, as it will affect their work in subsequent exercises.)
   - What are some examples of possible obstacles to food security (causes of food insecurity)? What particular dimension of food security do these obstacles undermine?
   - Which dimensions of food security are associated with the most numerous or obvious obstacles (in other words, which rows of the table at the end of the handout did students find easiest to fill)? What are the implications of this observation, and are these obstacles necessarily the most important?

Collect the reading guides at the conclusion of the discussion; instruct students to keep Handout 2 for future reference.

2. (30–40 minutes) Distribute one copy of Handout 4, *Measuring Poverty and Hunger,* to each student. Give students the remainder of the period

to read the handout and answer the questions; students may work in pairs or small groups if they wish. The instructor should circulate throughout the room during this time to answer questions and keep groups on track.

3. At the end of the class period, collect Handout 4 and distribute one copy of Handout 5, *Poverty and Hunger Data Activity,* to each student (the instructor may also distribute this exercise as students complete Handout 4, if students finish early). Ask students to complete the exercise for homework. Inform students that they will take a short quiz on the material that they have covered thus far at the beginning of the next class period.

Day Three

1. (10 minutes) Distribute one copy of Handout 6, *Quiz,* to each student. Give students about 10 minutes to work on the quiz, and then collect the quizzes for evaluation.
2. (10 minutes) Display Projection 2, *Poverty and Hunger Trends,* on a projector, and ask students to take out their completed copies of Handout 5. Review Handout 5 as follows:
   - Review questions 1–7 briefly, calling on students to provide answers and correcting their responses as necessary. Record the answers on a whiteboard or chalkboard. Refer to the Answer Key, and explain the answers with reference to the charts and maps, as appropriate.
   - Allow time for several students to comment at greater length on questions 8 and 9. While reviewing question 8c, list students' "third factors" on a whiteboard or chalkboard. While reviewing question 9, create a similar list of statistics/information that students would use in locating their program. Encourage students to add classmates' ideas to their own handouts, and leave these lists up for student reference for the remainder of the period.
3. (10 minutes) Distribute one copy of Handout 7, *Exploring Food Security Factors,* to each student. Ask students to spend about 10 minutes working on steps 1 and 2 with a partner or in a small group.
4. (10 minutes) After 10 minutes, bring the class back together to discuss part 2. Call on each pair or small group to share a factor from one of the categories on the handout and to briefly explain why they placed the factor in that category.
5. (10 minutes) Ask students to read the instructions for part 4 of the exercise. Have each student choose a sub-Saharan African country to research, or assign a unique country to each student. Give students the remainder of the period to being researching their country's food security situation. Make Internet-ready computers available for student research use.
6. Ask students to complete Handout 7, *Exploring Food Security Factors*, for homework. If students wish to keep Handout 5 as a reference, they may do so; collect both exercises for evaluation at the beginning of the next class period.

Day Four

1. (25 minutes) Divide the class into groups of five or six students. Ask students to sit in their groups and to take out their completed work on Handout 7, *Exploring Food Security Factors*. Distribute one poster board to each group. Give the groups about 25 minutes to complete the following tasks:
   - Have each group member give a brief (one to two minutes) presentation on the highlights of their country research, including their final assessment of the country's position along the food security continuum
   - As a group, discuss each member's research results. Agree on a ranking of the group's countries from most to least food secure.
   - Fix the group members' note sheets to the poster board in rank order; write each country's rank at the top of the note sheet.
   - Prepare to give a two-minute presentation to the class on the countries that the group ranked as most and least food insecure, focusing on no more than three key factors that affect food security in each.
2. (15 minutes) After 30 minutes, distribute one copy of Handout 8, *Group Presentation Notes,* to each student. Call the groups forward one at a time to give their presentations. Have students hang their posters on the board or on the classroom wall at the end of their presentation.
3. (10 minutes) Write the headings "Food Secure" and "Food Insecure" on a whiteboard or chalkboard. Ask students to volunteer common characteristics of each type of country from their presentation notes. Inform students that they will learn more about the characteristics and factors that determine food security status in upcoming lessons.
4. At the end of the class, collect Handout 8 for evaluation. Also collect Handout 5 from any students who kept the handout for reference.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess Handouts 1A–C, *Definition Guides: Food Security, Hunger,* and *Poverty,* based on
  - o the level of clarity, originality, and logical insight in the student's personal definitions;
  - o the student's demonstrated ability to access, interpret, and summarize official definitions from a variety of sources (consult Handout 4, *Measuring Poverty and Hunger*, for a summary of official definitions); and
  - o the level of detail, creativity, and logical insight in the student's responses to reflective and brainstorming questions.
- Assess Handout 3, *Reading Guide: Introduction to Basic Food Security Concepts,* based on:
  - o accuracy of the student's responses (use the Answer Key as a guide); and
  - o the level of detail, creativity, and logical insight in the student's descriptions of food insecurity factors.

- Assess Handout 4, *Measuring Poverty and Hunger,* based on
  - o accuracy of the student's responses (use the Answer Key as a guide); and
  - o the level of detail, creativity, and logical insight in the student's responses to reflective and open-ended questions.
- Assess the Quiz based on accuracy of the student's responses (use the Answer Key as a guide).
- Assess Handout 5, *Poverty and Hunger Data Activity,* based on
  - o accuracy of the student's responses to questions 1–7 (use the Answer Key as a guide); and
  - o the level of detail, creativity, and logical insight in the student's responses to open-ended questions (8 and 9).
- Assess Handout 7, *Exploring Food Security Factors*, based on
  - o accuracy and clarity of the four definitions given by the student in the graphic organizer;
  - o the level of detail, creativity, and logical insight in the student's responses to the "contributing factors" section of the graphic organizer (the instructor may with to consider the extent to which the student captured the key ideas raised in the group discussion);
  - o the level of effort demonstrated in the student's research notes:
    - Did the student populate each cell of the table with relevant and accurate information?
    - Are the notes neatly organized, with factors logically associated with the different dimensions of food security?
    - Did the student cite credible sources and provide an appropriate map?
    - Does the student's placement of the country on the food security continuum in the graphic organizer reflect the facts gathered in their research?
  - o the student's contribution to the group discussion (see suggestions for assessing group work, below); and
  - o the clarity, organization, and logic of the group presentation, including the strength of the group's logic in ranking their countries by food security status.
- Assess Handout 8, *Group Presentation Notes,* based on
  - o neatness, detail, and thoroughness; and
  - o the extent to which the student accurately captures and categorizes characteristics of food secure and food insecure countries (the instructor may wish to compare the student's notes with the lists of characteristics developed by the class as a whole).
- Assess contributions to group work and class discussion based on
  - o accuracy and appropriateness of contributions;
  - o clear and succinct statement of comments, questions, and answers;
  - o attention to other students' questions and ideas;

- ability to follow and promote lively, productive discussion;
- open-mindedness and respect for other students' backgrounds and opinions;
- willingness and ability to compromise and incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
- willingness and ability to express confusion and request clarification from other students and the instructor.

Definition Guide: Food Security

Instructions: Use this chart to summarize the definition and key characteristics of *food security*.

My definition:
What do you think *food security* means?
United Nations FAO (Food and Agriculture Organization) definition:
The UN FAO definition of *food security* is the most widely used. It is:
My definition (based on the UN FAO) of *food insecurity*:
Based on the FAO definition of *food security*, define the phrase in your own words:
Reflection on the UN FAO definition:
You will have a chance to discuss the UN FAO definition with a partner. Write your ideas here:
Brainstorm: Features of food security/insecurity
You know someone is food insecure, and you want to help. What additional information would you like to have about their situation? Brainstorm a list of questions that you would ask.

Definition Guide: Hunger

Instructions: Use this chart to summarize the definition and key characteristics of *hunger*.

My definition:
What does the term *hunger* mean to you? Write your personal definition here:
Dictionary definition:
Other definitions (governments, aid organizations, etc.):
If you find other definitions, write them in the space below. Cite your sources!
Brainstorm: Features of hunger
You know someone is hungry, and you want to help. What additional information would you like to have about his/her situation? Brainstorm a list of questions that you would ask.

Definition Guide: Poverty

Instructions: Use this chart to summarize the definition and key characteristics of *poverty*.

My definition:	
What does the term *poverty* mean to you? Write your personal definition here:	
Other definitions: Summarize a definition from each indicated source. Definitions may be complex; simply do your best to capture the key points.	
Source: Dictionary The World Bank The United Nations Other (optional)	Definition:
Brainstorm: Features of poverty You know someone is poor, and you want to help. What additional information would you like to have about his/her situation? Brainstorm a list of questions that you would ask.	

Introduction to Basic Food Security Concepts

Adapted with permission from "An Introduction to the Basic Concepts of Food Security," *Food Security Information for Action: Practical Guides*. Food and Agriculture Organization of the United Nations, 2008. Available online from: www.foodsec.org/docs/concepts_guide.pdf.

What does it mean to be *food secure* or *food insecure*?

According to the Food and Agriculture Organization of the United Nations (FAO), food security "exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." This definition, which was developed at the 1996 World Food Summit, suggests several key requirements for achieving global food security:

- Food must be *physically available*: The world's farming and livestock systems must produce enough food to meet minimum daily calorie requirements for the global human population. Improvements in *agricultural productivity* can help improve the physical availability of food.
- Food must be *physically accessible*: Everyone must have access to a local source of food, such as a personal farm, a nearby farm, a local market, or a grocery store. Note that physical accessibility may be difficult for people in remote regions, regions far from farming centers, and regions without developed roads and other transportation infrastructure. *Commercial trade* in food products, and *food aid* donations sponsored by governments and nonprofits, can help improve physical access to food.
- Food must be *economically accessible*: Everyone must be able to afford to purchase sufficient food from their local food sources (for individuals who rely on a small household farm for food, economic accessibility might mean being able to afford water, seed, fertilizer, and other inputs necessary to grow food). Various antipoverty strategies can help improve economic access to food.
- Food must be *safe and nutritious*: Local food sources must offer a variety of foods rich in protein, vitamins, and other nutrients essential for human life; food must be grown and transported under conditions that minimize the risks of food-borne illness and environmental damage, and that protect the health and safety of farmers and farm workers. Adjustments to agricultural *production practices* can sometimes help improve food safety and nutrition.
- The preceding requirements must be met *at all times*: Food production and distribution systems must be able to withstand both physical shocks (such as changes in global climate) and economic shocks (such as demand for food crops or agricultural inputs from the biofuel industry).

When these requirements are not met, we can say that a household, community, country, or even the world as a whole suffers from *food insecurity*. Note that while food insecurity can cause hunger and malnutrition, and may be a result of poverty, food insecurity is itself a distinct concept. For example, food insecure (or even malnourished) people may not be hungry on a regular basis if their food insecurity is due to a lack of *nutritious* food. Similarly, a moderately poor person need not necessarily be food insecure. The following definitions help to clarify these relationships:

- Hunger: an uncomfortable sensation caused by insufficient food energy consumption
- Malnutrition: the long-term result of deficiencies, excesses, or imbalances in calorie and nutrient consumption

- Poverty: deprivation related to economic consumption and food security, health, education, rights, voice, security, dignity, and decent work (adapted from the Organisation for Economic Co-operation and Development [OECD] definition of *poverty*).

Depending on which requirements for food security are and are not met—and on specific conditions of hunger, malnutrition, and poverty—food insecurity may be classified as chronic, transitory, or seasonal:

- Chronic food insecurity is long-term or persistent. It occurs when people are unable to meet their minimum food requirements over a sustained period of time, and it usually results from extended periods of poverty.
- Transitory food insecurity is short-term and temporary. It occurs when there is a sudden drop in the ability to produce or access enough food to maintain good nutritional status, and it usually results from short-term shocks and fluctuations in food availability and food access.
- Seasonal food insecurity is similar to chronic food insecurity, as it is usually predictable and follows a sequence of known events, but it is of limited duration and therefore can also be seen as recurrent transitory food insecurity. It occurs when there is a *cyclical pattern* of inadequate availability and access to food, associated with seasonal fluctuations in the climate, cropping patterns, work opportunities (labor demand), and disease.

Food security is a complex idea. Ensuring food security for any population or region—from a single household to the entire globe—requires overcoming physical constraints, such as the productivity of the world's agricultural systems, as well as economic constraints, such as the forces and dynamics that govern food prices. Food security may be disrupted by fluctuations in climate or in trade, by food-borne illnesses, or by political strife. You will learn more about these factors in subsequent lessons in this unit.

Reading Guide: Introduction to Basic Food Security Concepts

Review Handout 2, *Introduction to Basic Food Security Concepts*, and answer the following questions.

List the five requirements for food security:

1.

2.

3.

4.

5.

How is food availability different from food access?

Define each type of food insecurity in your own words:

1. Chronic food insecurity

2. Transitory food insecurity

3. Seasonal food insecurity

How is food insecurity different from hunger and malnutrition?

handout 3

How is food insecurity related to poverty?

Fill in the following table: In the left-hand column, list the five requirements for food security. In the right-hand column, for each requirement, describe a specific possible cause of food insecurity or a specific reason that the requirement might not be met. For example, international trade restrictions might be a "physical access" cause for a food-importing country.

Requirements for food security	Related causes of food insecurity
1.	
2.	
3.	
4.	
5.	

Measuring Poverty and Hunger

There are many possible definitions of the term *poverty*. Merriam-Webster's Collegiate Dictionary defines *poverty* as "a state of one who lacks a usual or socially acceptable amount of money or material possessions." Under the broader definition used by the United Nations, poverty is "a denial of choices and opportunities … lack of basic capacity to participate effectively in society."

Both of these definitions work well in that they help us understand what the word *poverty* means, but how do we know if someone is poor? What is a "usual or socially acceptable amount of money," and what gives a person or family the "basic capacity to participate effectively in society"? To measure and monitor poverty, we need a more rigorous quantitative definition; we need to attach numbers to these descriptions.

The number most often used to define poverty is an individual's daily consumption expenditure. When an individual falls below a certain expenditure level, they are classified as poor. The cutoff level is called the poverty line, and it is based on the costs of various essential goods and services: food, clothing, shelter, health care, etc. Poor individuals cannot afford enough of these goods and services to meet their daily needs.

daily consumption expenditure—the amount of money that an individual or a household spends per day on basic goods and services

poverty line—a cutoff level of daily consumption expenditure, below which an individual or household is classified as poor

There are many different poverty lines in use around the world today. The World Bank uses an *international poverty line* of $1.25 per day (or equivalent local currency) to measure and track global poverty. National governments usually define *national poverty lines* to reflect prices and living standards within their particular country. National poverty lines may be broken down further into *urban* and *rural* poverty lines, since prices and consumption patterns often differ significantly between urban and rural areas.

To describe the extent of poverty, we refer to the percentage of the global or national population whose daily consumption expenditure falls below the poverty line. This percentage is called the poverty headcount ratio. We can also describe the severity of poverty by measuring how far below the poverty line the average poor person's consumption expenditure falls. For example, if the poverty line is $1 per day and the average poor person spends only $0.80 per day, the average poor person lives 20% below the poverty line (1 – 0.8 = 0.2; 0.2/1 = .2 = 20%). In this case, we would say that the poverty gap is 20%.

poverty headcount ratio—the percentage of a population (global or national) whose daily consumption expenditure falls below the poverty line

poverty gap—the difference between an average poor individual's or household's daily consumption expenditure and the poverty line consumption expenditure, expressed as a percentage; the average "distance below" the poverty line

Like *poverty*, the term *hunger* lends itself to a range of interpretations. Most dictionary definitions describe hunger's subjective physical symptoms; for example, Merriam-Webster's Collegiate Dictionary defines hunger as "an uneasy sensation occasioned by lack of food." Again, however, we need to be more specific to measure and track hunger effectively.

Just as we used a daily expenditure threshold to measure poverty, we will use a daily calorie consumption threshold to measure hunger. The UN Food and Agriculture Organization classifies adults as undernourished

undernourishment—a state in which an individual consumes insufficient daily calories to "conduct sedentary or light activities" (FAO 2008)

Box 1: Why measure poverty and hunger?

This handout explains how national governments and international development organizations (such as the World Bank and the UN FAO) measure and track poverty and hunger. But why do we need to measure poverty and hunger in the first place? There are four key reasons:

1. Attaching numbers to poverty and hunger **highlights the severity of these problems**. The statement "one million people live in poverty" is more compelling, and is more likely to provoke action by the international community, than the statement "a lot of people live in poverty."
2. Detailed, quantitative information about poverty and hunger helps governments and aid agencies **target interventions**. If we can measure poverty and hunger accurately, we can also compare poverty and hunger within and across nations, and focus on helping the poorest and hungriest communities.
3. By monitoring changes in poverty and hunger over time, we can **evaluate the effectiveness of interventions**. For example, if a national government implements a job training program for poor citizens, they will need to know whether poverty rates fall in communities that participate in the program; if they do not, some aspects of the program may need to be changed.
4. Finally, measuring poverty and hunger helps us **evaluate the overall effectiveness of institutions** such as governments and development agencies. If a single government's poverty-reduction programs fail repeatedly, the problem may really stem from corruption or inefficiency within the government itself.

Adapted from Haughton, Jonathan and Shahidur Khandker. Handbook on Poverty and Inequality. *Washington, DC: The World Bank, 2009.*

or "food deprived" if their daily calorie consumption falls below a level estimated to be necessary to "conduct sedentary or light activities" (FAO 2008). The undernourishment threshold is called the minimum dietary energy requirement, and varies from country to country, somewhat like a national poverty line. The exact value depends on demographic factors such as the median age, gender ratio, and average weight and height in the country's population. You can download a complete country-by-country list of minimum dietary energy requirements from http://www.fao.org/economic/ess/ess-fs/fs-data/ess-fadata/en/. The threshold in most countries is between 1,700 and 2,000 kilocalories per day.

minimum dietary energy requirement—the minimum level of daily calorie consumption deemed necessary to "conduct sedentary or light activities" (the FAO maintains country-by-country estimates)

In some cases, we may find it useful to measure and track the symptoms of hunger, in addition to its causes (e.g., insufficient food consumption). The FAO maintains statistics on symptoms such as stunting (low height for age) and wasting (low weight for height) in children under age five for many countries. These statistics show how hunger affects the country's most vulnerable individuals.

stunting—low height for age; a symptom of undernourishment

wasting—low weight for age; a symptom of undernourishment

Box 2: Measuring progress toward the Millennium Development Goals

The United Nations' Millennium Development Goals are one example of how world leaders use quantitative measures of poverty and hunger to provoke action, target interventions, and track the effectiveness of programs and institutions. The eight goals represent a commitment by world leaders to pursue quantitative, time-bound targets for global development and poverty reduction. The goals were adopted at the UN Millennium Summit in September 2000 and have since, according to the UN, "galvanized unprecedented efforts to meet the needs of the world's poorest."

The goals are to:
1. Eradicate extreme poverty and hunger.
2. Achieve universal primary education.
3. Promote gender equality and empower women.
4. Reduce child mortality.
5. Improve maternal health.
6. Combat HIV/AIDS, malaria, and other diseases.
7. Ensure environmental sustainability.
8. Develop a global partnership for development.

Each goal is associated with specific quantitative or qualitative targets. For example, a target for Goal 1 is to halve (relative to 1990) the number of people in the world living on less than $1 per day. By using the measures of poverty and hunger described in this handout, UN leaders can make consistent, objective statements about progress toward the target. The UN has set a deadline of 2015 for achieving the first round of Millennium Development targets; you can track progress online at http://www.mdgmonitor.org/.

(Adapted from http://www.un.org/millenniumgoals/)

Questions:

1. What are the four main reasons to measure and track poverty and hunger? Which of these reasons do you think is the most important and why?

2. Why do you think different nations use different poverty lines?

3. Reread the definition of *minimum dietary energy requirement* in the handout. Do you see any potential problems with basing the minimum dietary energy requirement on the demographic factors listed in the definition? Which countries would you expect to have the highest requirements under this definition? The lowest?

4. In 2010, the United States' poverty line was $22,314 for a family of four. What was the per-person, per-day poverty line? How does this poverty line compare with the World Bank's international poverty line? How would you account for the difference?

5. Suppose you lived just below the World Bank's international poverty line. Do you think you could meet your minimum dietary energy requirement? What foods would you buy, and what foods or food groups would you have to forgo?

6. Box 2 describes how UN leaders use quantitative measures of poverty and hunger to track progress toward the first Millennium Development Goal. For Goals 2–8, propose a similar quantitative measure that you could use to set targets and track progress:

   Goal 2: Achieve universal primary education.

   Goal 3: Promote gender equality and empower women.

   Goal 4: Reduce child mortality.

   Goal 5: Improve maternal health.

Goal 6: Combat HIV/AIDS, malaria, and other diseases.

Goal 7: Ensure environmental sustainability.

Goal 8: Develop a global partnership for development.

Poverty and Hunger Data Activity

Use the charts and map on pages 32–33 to answer the following questions:

1. Which region of the world is home to the greatest **number** of people living on $1.25 or less per day?

2. In which region of the world does the highest **percentage** of the population live on $1.25 or less per day?

3. Why are your answers to (1) and (2) different?

4. Which region(s) of the world experienced the greatest reduction in poverty between 1990 and 2005?

5. Which region(s) of the world experienced the least reduction in poverty between 1990 and 2005?

6. Which region(s) of the world has the highest rates of undernourishment?

7. Which regions or countries have made the most progress toward meeting the Millennium Development hunger target? Which have made the least progress?

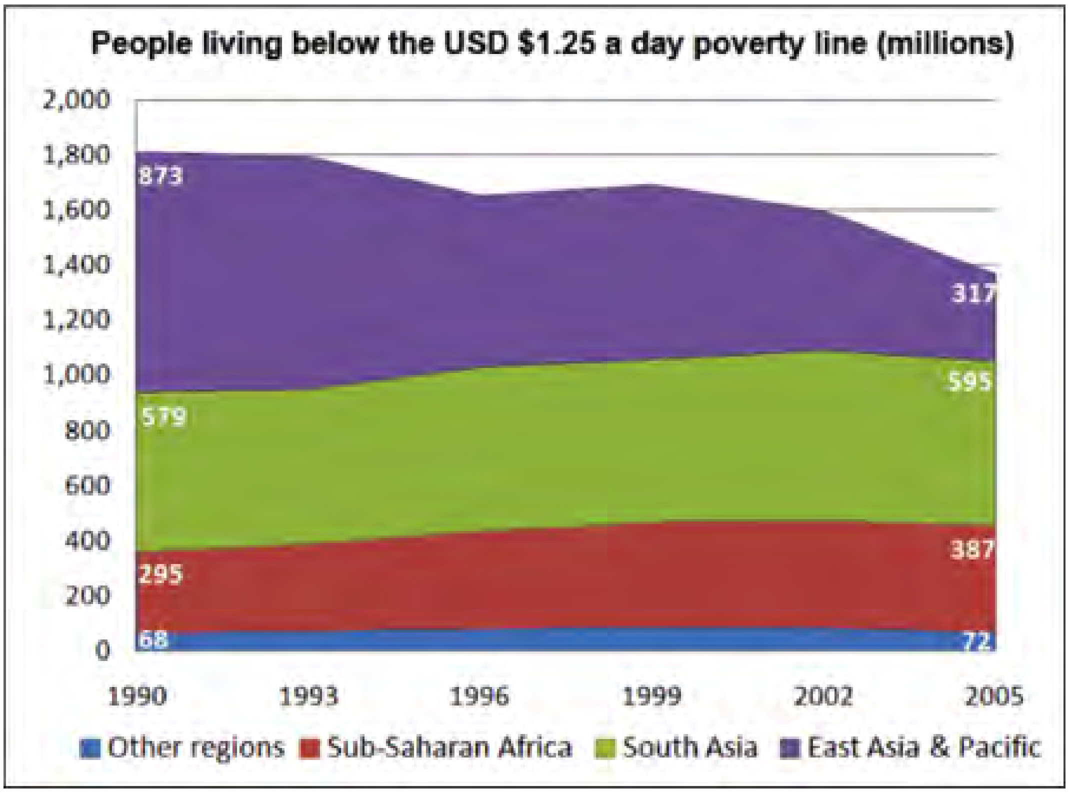
8. The charts and map in this handout show a strong **correlation** between hunger and poverty—high rates of hunger and poverty tend to occur in the same countries and regions. However, demonstrating correlation is not enough to conclude that poverty causes hunger or vice versa. Draw on your understanding of hunger, poverty, and food security to defend each of the following statements (you may wish to refer to Handout 2, *Introduction to Basic Food Security Concepts*):

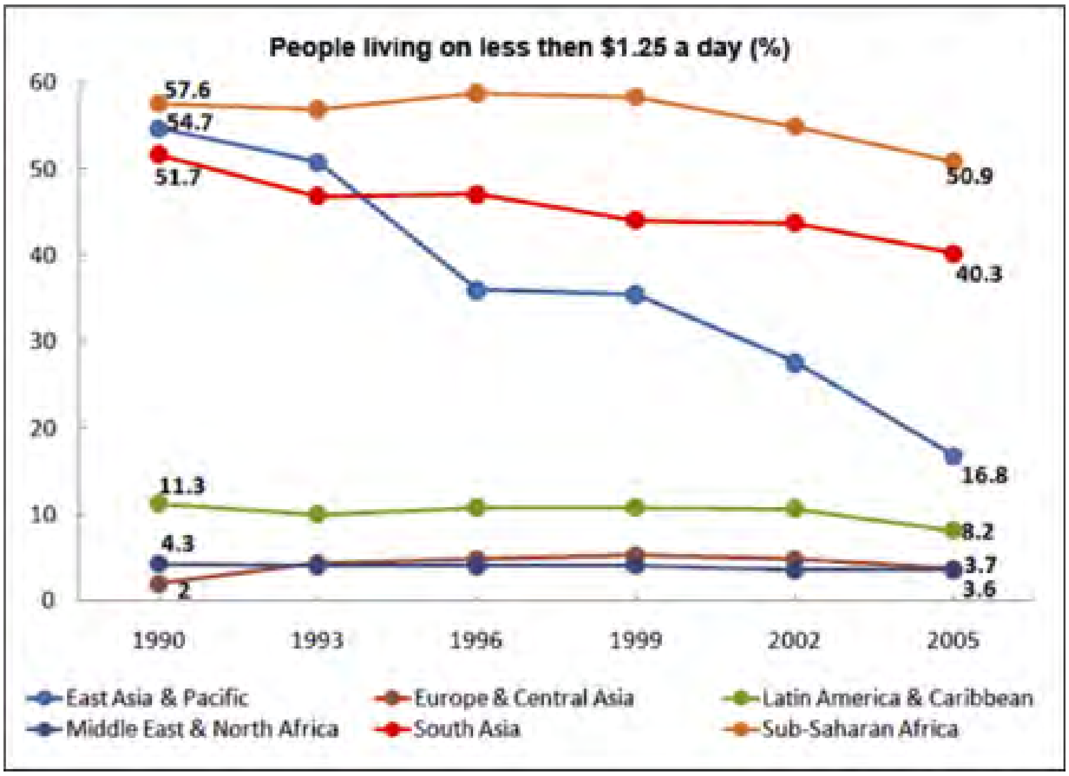
   a. Poverty causes hunger.

   b. Hunger causes poverty.

   c. A third factor, ____________________ , causes both poverty and hunger.

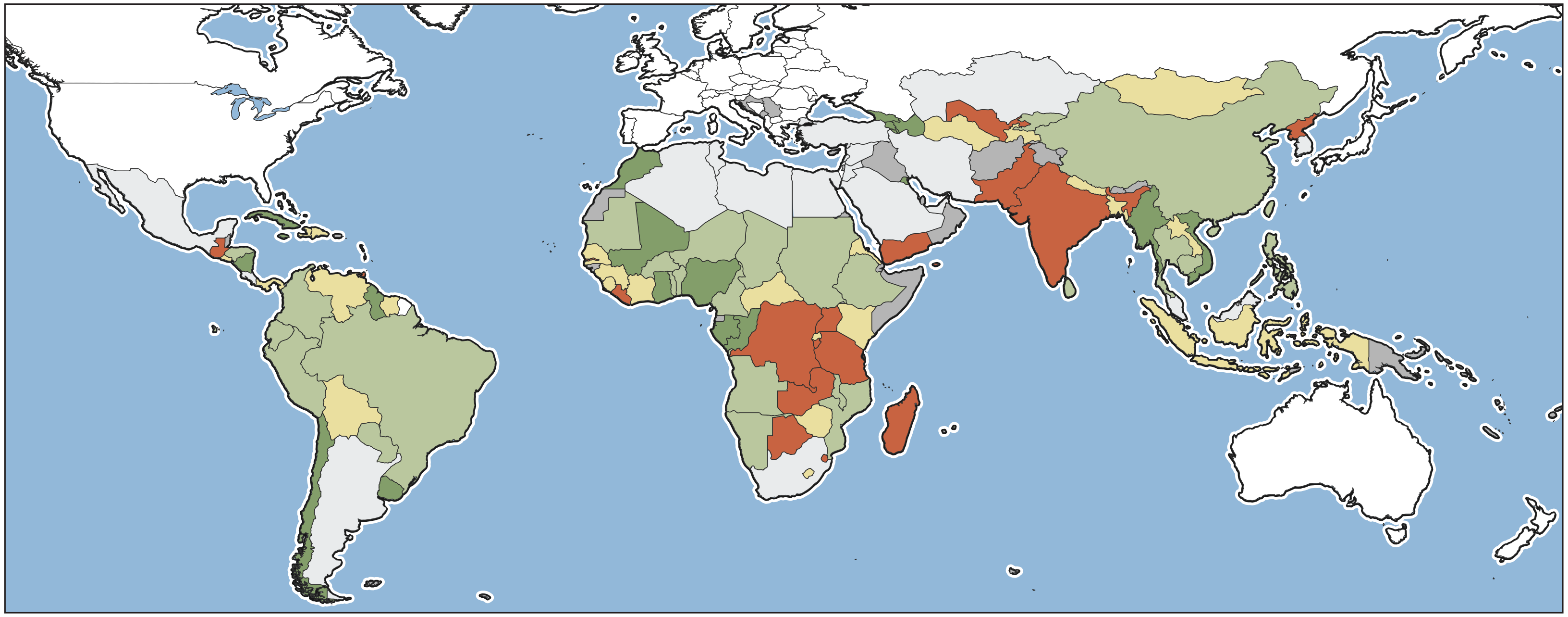
9. The sub-Saharan African countries of Madagascar and Niger had approximately the same $1.25 per day poverty rate in 2005 (about 65%). Suppose that you are planning to implement a program to improve food security in one of these two countries. What other statistics and information could you gather (beyond the poverty and undernourishment rates) that would help you decide where to locate your program? List at least five ideas below, and briefly explain how you would use each piece of information (i.e., if the country had__________ , I would be more/less likely to locate the program there):





Source: World Bank

Progress towards Millennium Development Goal 1: Hunger Target 2010



Source: FAOSTAT 2010 (www.fao.org/hunger)

Progress achieved (1990-92 to 2005-07)

- Already met MDG 1 or very close to meeting the target
- Progress sufficient to reach MDG 1 if prevailing trends persist
- Progress insufficient to reach MDG 1 if prevailing trends persist
- No progress or deterioration
- Not relevant - prevalence of hunger was below 5% in 1990
- Missing or insufficient data

Note: Target 1C of the first Millennium Development Goal seeks to halve, between 1990 and 2015, the proportion of people who suffer from hunger. The calculation of progress compares the latest available country-level information on the prevalence of undernourishment (2005-07) with the rates that existed in 1990-92 (the base period for the hunger target). The projection for 2015 assumes that the trends between both periods continue in the future. Developed countries are not considered.

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QUIZ

1. List the five requirements for food security:

2. Define each of the following terms. Use clear, concise language. You may give an official definition, a dictionary definition, or a definition in your own words, as long as you accurately capture the meaning of the term.

   a. Hunger:

   b. Poverty:

   c. Food security:

3. Explain how you would determine a country's **poverty headcount ratio** at the **international poverty line**.

4. Explain how you would determine a country's **undernourishment rate**.

5. List three reasons to measure and track hunger and poverty.

6. In which region of the world does the highest **percentage** of the population live in poverty?

Exploring Food Security Factors

In this exercise, you will work in small groups and as a class to organize and summarize your understanding of poverty, hunger, and food security. Refer to the graphic organizer provided with this handout as you carry out the following steps:

1. Fill in the bubbles in the organizer with clear, concise definitions for the terms poverty, hunger, food insecurity, and food security.

2. With a partner or in a small group, brainstorm factors that contribute to food insecurity by disrupting or undermining any of the five dimensions of food security (you may wish to refer to your work on Handout 3, *Reading Guide: Introduction to Basic Food Security Concepts*, for some initial ideas). Consider factors related to a country's natural resources, social demographics (population growth rate, disease prevalence, literacy, etc.), and national and regional politics and economics; think broadly about how these factors might affect food security. Your factors may be general or specific; aim for a balance of each. Record your list in the arrow above the "food insecurity" bubble.

3. Discuss the brainstorming activity as a class, and add your classmates' factors to those listed by your small group.

4. Evaluate food insecurity factors in a specific case: Choose a sub-Saharan African country from the list in Box 1 and **research its food security situation** (your teacher may also assign you to a country). Consider the country's hunger and poverty rates, but be sure to look at other factors as well, especially those that you listed in steps (2) and (3). Hunger and poverty are prevalent in much of sub-Saharan Africa, but many of these countries have made important strides toward food security and overall stability that may not be apparent in basic poverty and hunger statistics.

   The following Web sites may be helpful in your research:
   - The World Bank's "Countries" page: www.worldbank.org;
   - The U.S. State Department's country background notes: http://www.state.gov/misc/list/index.htm;
   - The UN Food and Agriculture Organization's hunger portal: http://www.fao.org/hunger/en;
   - The UN Millennium Development Goal Monitor: http://www.mdgmonitor.org

   Use the table on the next page to organize and record your research. You will present this table to your classmates, so be sure to keep your notes neat and organized. When you have completed the table to the best of your ability, evaluate the country's overall food security status by writing its name somewhere along the continuum from more to less food secure on the right-hand side of the graphic organizer. As you choose a position for your country, imagine a perfectly food secure and a perfectly food insecure country at either end of the continuum. What might those countries' environments, demographics, and political and economic systems look like?

Print a small map showing your country's location, and paste or tape it below your table of notes. You will present your notes, map, and assessment of the country's food security situation during class discussion.

Box 1: Sub-Saharan Africa (SSA)

SUB-SAHARAN AFRICAN COUNTRIES	
Angola	Lesotho
Benin	Liberia
Botswana	Madagascar
Burkina Faso	Malawi
Burundi	Mali
Cameroon	Mauritania
Cape Verde	Mauritius
Central African Republic	Mozambique
Chad	Namibia
Comoros	Niger
Congo, Dem. Rep.	Nigeria
Congo, Rep.	Rwanda
Côte d'Ivoire	Säo Tomé and Principe
Dijbouti	Senegal
Equatorial Guinea	Seychelles
Eritrea	Sierra Leone
Ethiopia	South Africa
Gabon	South Sudan
The Gambia	Swaziland
Ghana	Tanzania
Guinea	Togo
Guinea-Bissau	Uganda
Kenya	Zambia
	Zimbabwe

The countries that lie south of Africa's Sahara Desert are among the poorest in the world. Per-capita income in this region averages less than 15% of the global average. In 2005, the regional poverty rate stood at 50%. Life expectancy is just 52 years, and roughly a quarter of the population is undernourished.

Many factors have contributed to sub-Saharan Africa's long struggle with hunger and poverty. The region suffers from high rates of HIV/AIDS infection and from a high prevalence of malaria, tuberculosis, and other communicable diseases. Literacy rates are low, especially among women. Ethnic strife and civil conflicts have disrupted relief and development efforts in many countries. Almost all agriculture in the region is rainfed; few of the region's many small farmers have consistent access to modern advantages such as irrigation, fertilizer, and machinery. And although a large share of the regional population continues to live in rural areas and work in agriculture, millions of sub-Saharan Africans have migrated to cities in the past three decades. National governments have struggled to manage the growth of the urban population, accelerate urban and industrial development, and provide productive employment for new city dwellers.

Fortunately, however, sub-Saharan Africa has benefitted from international development aid and prudent pro-poor government policies over the past 15 years. Regional economic output has grown at rates in excess of 5% per year (compared with about 4% for the world as a whole). School enrollment has increased, child mortality is declining, and the rate of HIV/AIDS infection is stabilizing. Some warring ethnic groups have reconciled with the help of international facilitators, and citizens, including women, are beginning to take a more active role in government. According to the World Bank, if these trends continue, sub-Saharan Africa could be "on the brink of an economic takeoff."

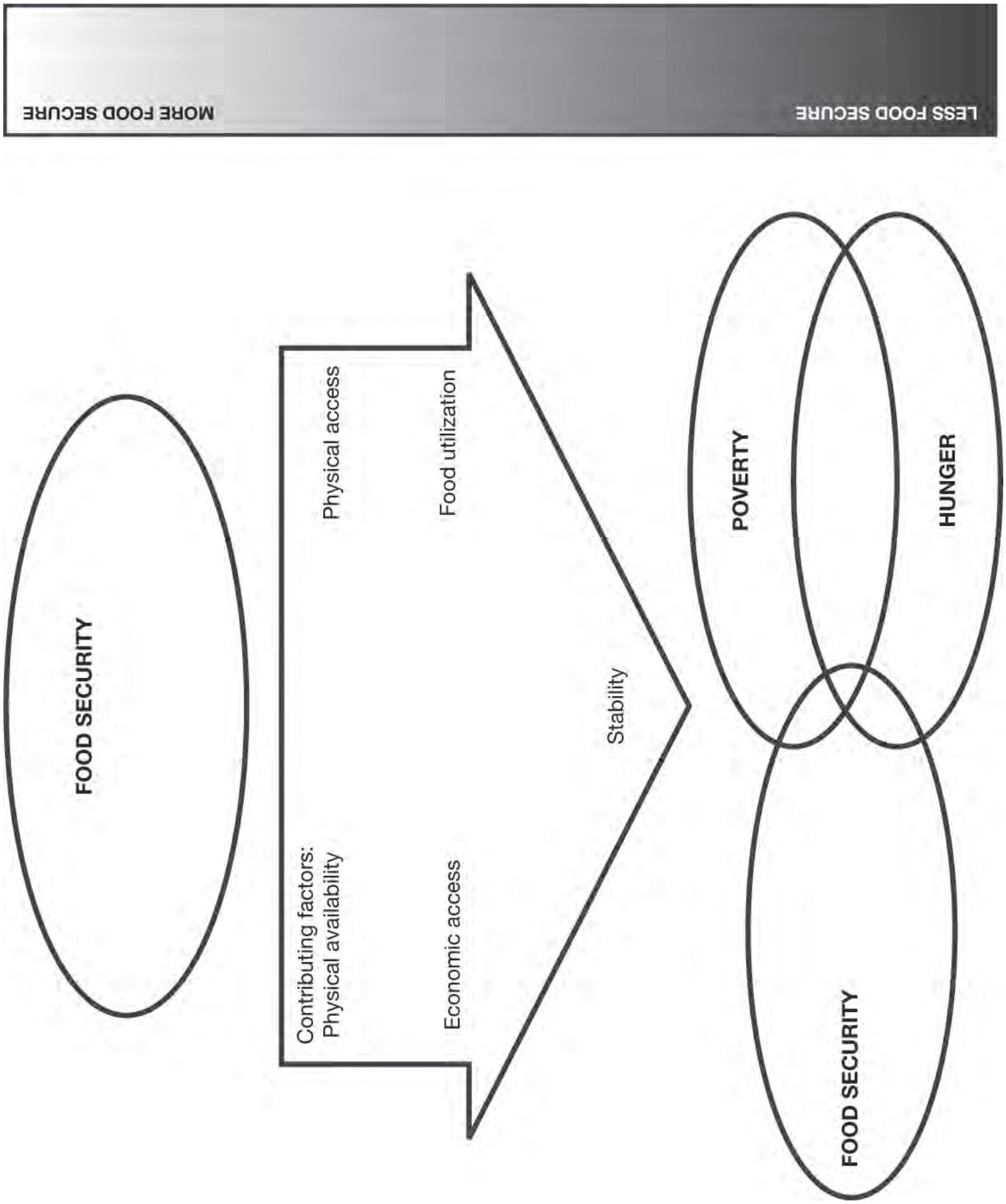
Choose a country from the list in Box 1. Use this table to organize your research on your country's food security situation:

Country:

	Contributes to this dimension of food security:	Disrupts this dimension of food security:
Physical availability of food (food production)		
Physical access to food		
Economic access to food		
Food utilization		
Stability		
Sources:		

Map showing this country's location:

Place your sub-Saharan African country along this continuum:



Group Presentation Notes

As you listen to the group presentations, record key characteristics of most- and least-food-secure countries in the following table. Try to categorize characteristics based on the dimension of food security that they affect the most.

Characteristics related to:	Most-food-secure countries tend to have:	Least-food-secure countries tend to have:
Physical availability of food (food production)		
Physical access to food		
Economic access to food		
Food utilization		
Stability		

FAO Food Security Definition

The United Nations Food and Agriculture Organization defines food security as follows:

"Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life."

(This definition was developed and adopted at the 1996 World Food Summit.)

Discuss the following questions with a neighbor:

1. How is the FAO definition similar to definitions proposed by the class? How is it different?

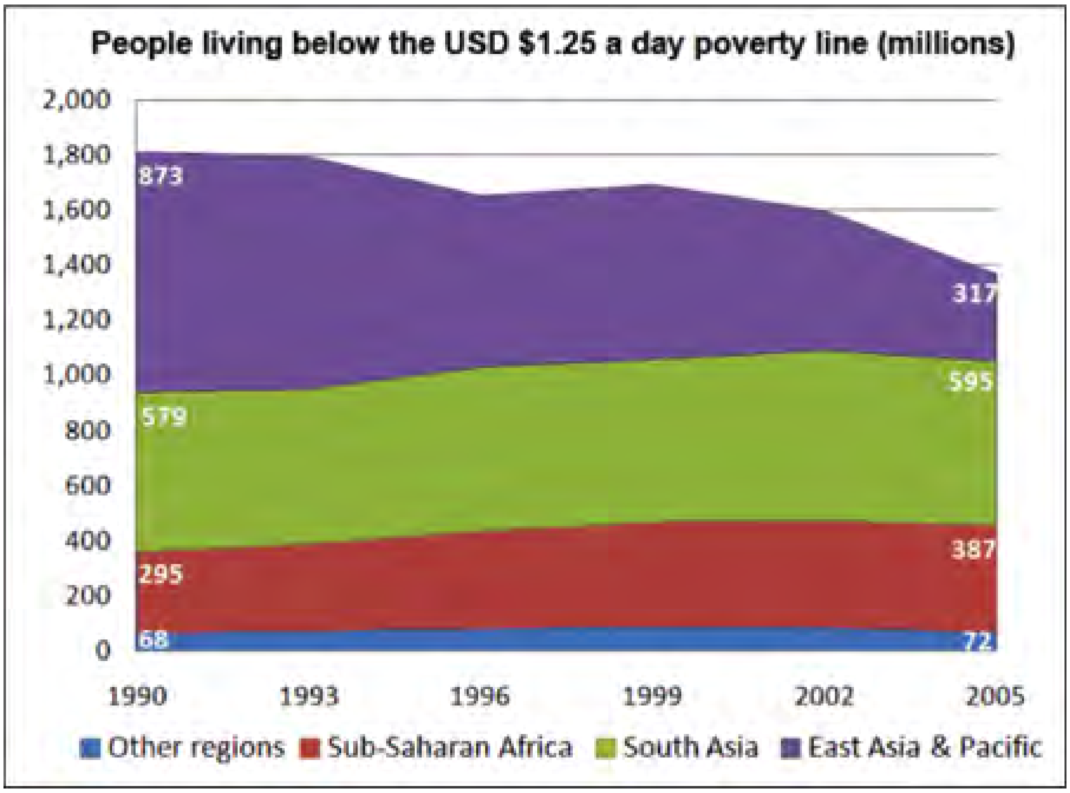
2. Do you think that the FAO definition is a good definition?

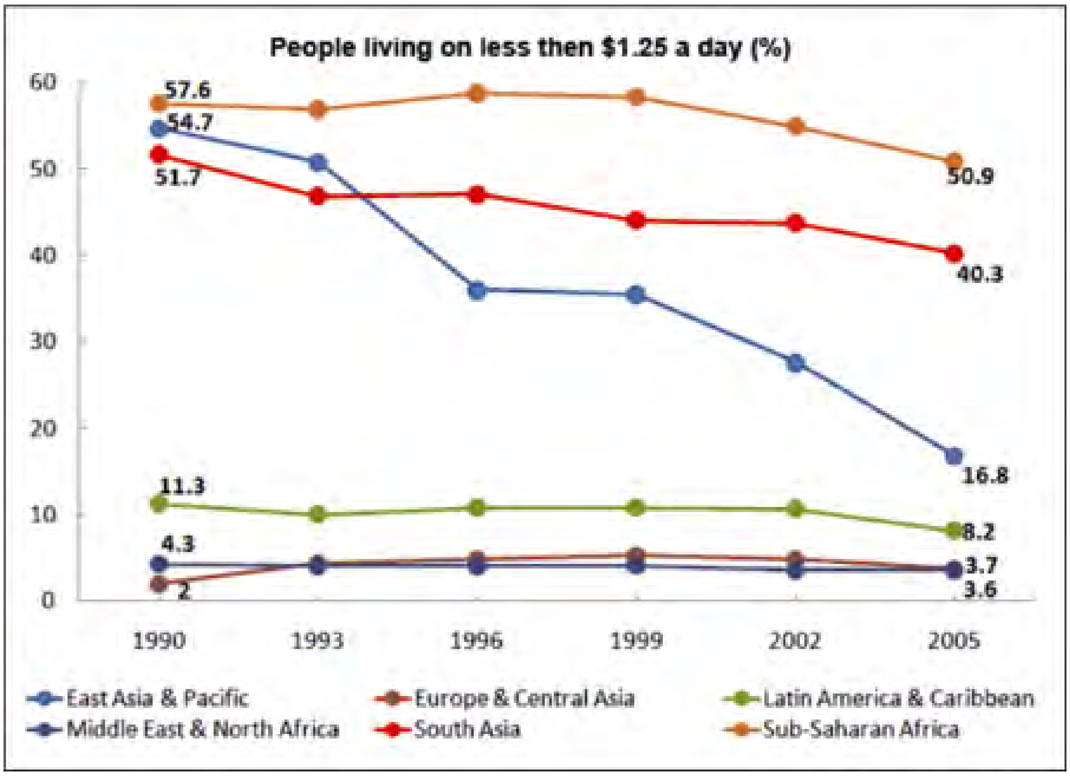
a. Could you classify people, households, or nations as food secure or insecure based on this definition?

b. Does the definition use straightforward language? Do you understand all the terms used in the definition?

c. Would you add any clarifications or qualifications? If so, what?

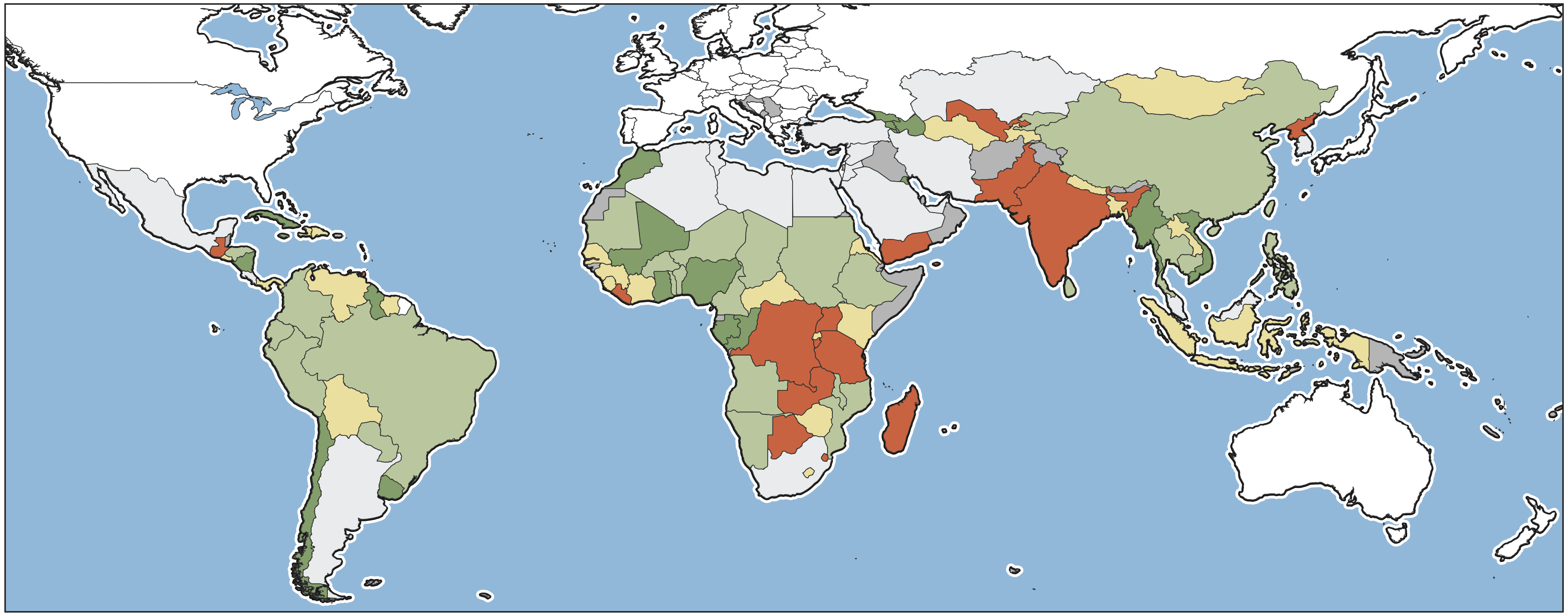
Poverty and Hunger Trends





Source: World Bank

Progress towards Millennium Development Goal 1: Hunger Target 2010



Source: FAOSTAT 2010 (www.fao.org/hunger)

Progress achieved (1990-92 to 2005-07)

- Already met MDG 1 or very close to meeting the target
- Progress sufficient to reach MDG 1 if prevailing trends persist
- Progress insufficient to reach MDG 1 if prevailing trends persist
- No progress or deterioration
- Not relevant - prevalence of hunger was below 5% in 1990
- Missing or insufficient data

Note: Target 1C of the first Millennium Development Goal seeks to halve, between 1990 and 2015, the proportion of people who suffer from hunger. The calculation of progress compares the latest available country-level information on the prevalence of undernourishment (2005-07) with the rates that existed in 1990-92 (the base period for the hunger target). The projection for 2015 assumes that the trends between both periods continue in the future. Developed countries are not considered.

The designations employed and the presentation of material in the map do not imply the expression of any opinion whatsoever on the part of FAO concerning the legal or constitutional status of any country, territory or sea area, or concerning the delimitation of frontiers.

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Answer Key to Handout 3
(Reading Guide: Introduction to Basic Food Security Concepts)

Review Handout 2, *Introduction to Basic Food Security Concepts,* and answer the following questions:

List the five requirements for food security:

1. *Physical availability of food*
2. *Physical access to food*
3. *Economic access to food*
4. *Food safety and nutrition*
5. *Stability of food security in the face of physical and economic shocks*

How is food availability different from food access?

Food availability refers to the amount of food that exists for human consumption, and is most affected by global crop production. Food access refers to households' and individuals' ability to acquire food, and comprises both physical factors (ability to store and transport food, for example) and economic factors (sufficient income to purchase food).

Define each type of food insecurity in your own words:

1. Chronic food insecurity

Answers will vary; students should mention that chronic food insecurity is long-lasting and results from deep poverty and inadequate access to resources.

2. Transitory food insecurity

Answers will vary; students should mention that transitory food insecurity lasts for only a brief period, is known to be temporary, and results from short-term fluctuations in crop output, employment, and income status, etc.

3. Seasonal food insecurity

Excellent answers will also note that seasonal food insecurity has characteristics of both chronic and transitory food insecurity—it is fundamentally predictable and continual, but occurs in brief, transitory episodes.

How is food insecurity different from hunger and malnutrition?

Hunger and malnutrition are symptoms of food insecurity; because food insecurity also encompasses stability of access and quality of food, it is possible to be food insecure without being hungry or even necessarily malnourished.

How is food insecurity related to poverty?

Food insecurity is a common—but not inevitable—consequence of poverty.

Note: Food insecurity can also be a cause of poverty. Hunger and malnutrition lower productivity, and lead to poor social and cognitive development, increasing an individual's lifelong risk of poverty. For example, poor nutrition as a child might make an adult more susceptible to diseases and disorders that disqualify him or her from higher-paying jobs.

Fill in the following table: In the left-hand column, list the four dimensions of food security. In the right-hand column, for each dimension, describe a specific possible cause of food insecurity related to that dimension. For example, international trade restrictions might be a "physical access" cause for a food-importing country.

Dimension	**Related Cause** *Answers will vary; examples are provided below.*
1. *Physical availability*	*A drought results in crop failures in the world's major grain-producing regions.*
2. *Physical access*	*A country lacks basic transportation infrastructure (roads, ports, etc.) to carry fresh food to remote rural areas.*
3. *Economic access*	*Death of the male head of a family leaves the remaining members with no income.*
4. *Safety and nutrition*	*A rural village lacks the infrastructure (refrigeration) to safely store fresh meat, dairy, and vegetables, resulting in wasted food and sickness among those who consume spoiled products.*
5. *Stability*	*Civil war threatens a region's farm systems and infrastructure; climate change makes the future of regional agriculture uncertain.*

Answer Key to Handout 4 (Measuring Poverty and Hunger)

1. What are the four main reasons to measure and track poverty and hunger? Which of these reasons do you think is the most important and why?
   Four reasons: highlight the severity of the problem, target interventions, evaluate interventions, and evaluate institutions.
   Answers to the second part of the question will vary. Students should make a clear statement regarding which factor they consider most important, and defend their choice with a logical argument that highlights connections between the four reasons. Example: The most important reason is to highlight the severity of the problem because appropriate interventions will never occur if world leaders aren't concerned about poverty and hunger. Without any institutional intervention at all, the next three reasons are meaningless.

2. Why do you think different nations use different poverty lines?
   Answers will vary somewhat, but should reflect the following basic points: (1) the national poverty line is based on prices and living standards in a particular country; (2) prices and living standards vary widely between countries—for example, the cost of living in a U.S. city is much higher than the cost of living in a rural African village.

3. Reread the definition of minimum dietary energy requirement in the handout. Do you see any potential problems with basing the minimum dietary energy requirement on the demographic factors listed in the definition? Which countries would you expect to have the highest requirements under this definition? The lowest?
   Answers will vary somewhat, but should reflect the insight that undernourishment itself affects these demographic factors, because low food availability favors survival by members of the population who require fewer calories per day. In particular, the average population height and weight will be lower when food intake is low. Thus, as a country's undernourishment rate increases, estimates of the minimum dietary energy requirement will actually be lower, masking the escalation in food insecurity.

4. In 2010, the United States' poverty line was $22,314 for a family of four. What was the per-person, per-day poverty line? How does this poverty line compare with the World Bank's international poverty line? How would you account for the difference?
   $22,314 divided by four people per family, divided by 365 days per year equals about $15 per day, much more than the international poverty line of $1.25 per day. The reason is covered in Question 2 — prices and living standards in the United States are higher than the international average. The difference in living standards is particularly important. Because the basic expectations that define "not poor" among U.S. residents include amenities such as a permanent living structure, a car, etc., the poverty line is much higher.

5. Suppose you lived just below the World Bank's international poverty line. Do you think you could meet your minimum dietary energy requirement? What foods would you buy, and what foods or food groups would you have to forgo?
   Answers will vary. Award points for thorough, logical, and thoughtful answers that reflect knowledge or basic research regarding the prices and calorie content of different food groups. Students should recognize that they would need to survive mostly on basic staple grains and/or (especially in developed countries) cheap, less nutritious fast food, while forgoing more expensive products such as meat and fresh produce.

6. Box 2 describes how UN leaders use quantitative measures of poverty and hunger to track progress toward the first Millennium Development Goal. For Goals 2–8, propose a similar quantitative measure that you could use to set targets and track progress:
Answers will vary; suggestions are provided for each indicator below

Goal 2: Achieve universal primary education.

Literacy rate, school enrollment rate

Goal 3: Promote gender equality and empower women.

Male-female income ratio, proportion of elected government positions held by women

Goal 4: Reduce child mortality.

Child mortality rate, infant and child immunization rates

Goal 5: Improve maternal health.

Percentage of women receiving prenatal care, percentage of pregnant women dying in childbirth, percentage of low-birthweight babies

Goal 6: Combat HIV/AIDS, malaria, and other diseases.

HIV/AIDS infection rate, percentage of HIV/AIDS patients receiving antiretroviral drugs, ratio of physicians to total population, treatment and infection rates for malaria and tuberculosis

Goal 7: Ensure environmental sustainability.

Global and country-by-country carbon emissions (tons of carbon dioxide equivalent per year), deforestation rates (hectares per year), water and energy use

Goal 8: Develop a global partnership for development.

Value of international development aid from developed to less-developed countries, trade balances (value of exports vs. imports) of developing countries, number of developing country representatives in international forums

Answer Key to Handout 5 (Poverty and Hunger Data Activity)

1. In 2005, which region of the world was home to the greatest **number** of people living on $1.25 or less per day?
   South Asia, with 595 million (first chart)

2. In 2005, in which region of the world did the highest **percentage** of the population live on $1.25 or less per day?
   Sub-Saharan Africa, with 50.9% (second chart)

3. Why are your answers to (1) and (2) different?
   The population of South Asia is much greater than the population of sub-Saharan Africa; in fact, South Asia has a population of 1.6 billion, while sub-Saharan Africa's is only 850 million (2010 data, World Bank). Thus, a smaller number represents a higher percentage in sub-Saharan Africa.

4. Which region(s) of the world experienced the greatest reduction in poverty between 1990 and 2005?
   East Asia and Pacific (either chart)

5. Which region(s) of the world experienced the least reduction in poverty between 1990 and 2005?
   Sub-Saharan Africa, South Asia (either chart)

6. Which region(s) of the world has the highest rates of undernourishment?
   From the second map, we can see that undernourishment is concentrated in sub-Saharan Africa, Central and South America, and Asia/South Asia. Undernourishment is most widespread and severe in sub-Saharan Africa.

7. Which regions or countries have made the most progress toward meeting the Millennium Development hunger target? Which have made the least progress?
   Note: Darker greens indicate more progress; yellows and oranges indicate less progress. Northwest sub-Saharan Africa, several South American countries, and much of South Asia have made good progress; lack of progress (or regression) is notable in south-central Africa, India, and Pakistan.

8. The charts and maps in this handout show a strong **correlation** between hunger and poverty—high rates of hunger and poverty tend to occur in the same countries and regions. However, demonstrating correlation is not enough to conclude that poverty causes hunger or vice versa. Draw on your understanding of hunger, poverty, and food security to defend each of the following statements (you may wish to refer to Handout 2, *Introduction to Basic Food Security Concepts*):
   a. Poverty causes hunger.
      It is difficult to buy food, or the assets and infrastructure used to produce food (seeds, land, farm machinery, etc.) if you are poor.
   b. Hunger causes poverty.
      If you are hungry, you may not have the energy to work. You will be more susceptible to diseases that will reduce your productivity.

c. A third factor, ___________________ , causes both poverty and hunger.
Answers will vary; the goal of the question is for students to think about how different external factors affect hunger and poverty. Some possible "third factors" are poor natural resource endowments (i.e., unfavorable climate for agriculture), inefficient or counterproductive government policies (corruption, trade policies that hurt local producers, etc.), regional health crises, etc. Students should pick a third factor and clearly explain how it affects both poverty and hunger.

9. The sub-Saharan African countries of Madagascar and Niger had approximately the same $1.25 per day poverty rate in 2005 (about 65%) and undernourishment rates of 25 and 16 percent, respectively. Suppose that you are planning an antipoverty program to be implemented in one of these two countries. What other statistics and information could you gather (beyond the poverty and undernourishment rates) that would help you decide where to locate your program? List at least five ideas below.
Answers will vary. Possible answers include: the poverty gap, the prevalence of HIV/AIDS or other chronic diseases, the country's natural resource endowments and agricultural productivity, the strength of the country's infrastructure, the structure of the country's government. The goal of the question is to encourage students to begin thinking about different factors that cause and exacerbate food insecurity—in particular, factors that might make it harder or easier for the country to improve food security without external assistance. Students should clearly explain what they would look for in making a decision about where to locate the program. There is no one right answer; for example, one student might argue that a country with poor government needs more help, while another might argue that the government's inefficiency will prevent the program funds from being used effectively.

Answer Key to Handout 6 (Quiz)

1. List the five requirements for food security:
   Physical availability of food; physical access to food; economic access to food; food safety and nutrition; and stability of food security in the face of physical and economic shocks

2. Define each of the following terms. Use clear, concise language. You may give an official definition, a dictionary definition, or a definition in your own words, as long as you accurately capture the meaning of the term.
   Answers will vary; give credit for clear, concise responses that capture the key elements of the formal definitions below.
   a. Hunger:
   The physical sensation caused by lack of food; a craving or urgent need for food or nutrients; weakness brought on by long-term food deprivation
   b. Poverty:
   "A state of one who lacks a usual or socially acceptable amount of money or material possessions" (Merriam-Webster's Collegiate Dictionary);
   "A denial of choices and opportunities … lack of basic capacity to participate effectively in society." (United Nations)
   c. Food security:
   "…all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." (FAO)

3. Explain how you would determine a country's **poverty headcount ratio** at the **international poverty line**.
   Determine the number of people in the country whose daily consumption expenditure is less than $1.25 per day, and divide that number by the country's total population (the poverty headcount ratio is expressed as a percentage of the total population).

4. Explain how you would determine a country's **undernourishment rate**.
   Conduct surveys or consult the FAO databases to determine the country's ***minimum dietary energy requirement****. Determine the number of people whose daily calorie consumption is below the requirement, and divide by the country's total population.*

5. List three reasons to measure and track hunger and poverty:
   Four possible reasons listed on Handout 4, Measuring Poverty and Hunger*: highlight the severity of global poverty and hunger; target interventions; evaluate interventions; and evaluate institutions.*

6. In which region of the world does the highest percentage of the population live in poverty?
   Sub-Saharan Africa

Lesson Two

Food Production

Organizing Questions

- Which crops are most important for global food security and why?
- How and why are spatial and temporal trends in crop productivity correlated with trends in hunger and poverty?
- What was the Green Revolution, how did it come about, and how did it affect poverty, food security, and environmental quality in the developing world?

Introduction

This lesson explores trends in physical availability of food as determined by local and global agricultural productivity. Students learn about common measures of agricultural productivity and apply these measures to compare the productivity of different crops and regions over time. At the end of the lesson, students learn about the Green Revolution, a series of major developments in agricultural technology and policy that dramatically increased crop productivity in the latter half of the 20th century. The lesson activities highlight connections between global agricultural productivity and hunger and poverty in the developing world, and encourage students to recognize the positive and negative food security effects of productivity-enhancing technologies.

Objectives

In this lesson, students will

- learn how crop productivity is measured and apply common productivity measures to compare the productivity of different crops and regions over time;
- recognize correlations between crop productivity, hunger, and poverty;
- learn what the Green Revolution was, explain why and how it occurred, and appreciate its positive and negative effects; and
- practice taking notes and filtering relevant information while viewing a clip from an academic lecture.

Materials

- Handout 1, *Crop Productivity*
- Handout 2, *Mapping Crop Productivity*
- Handout 3, *Time Trends in Crop Productivity*
- Handout 4, *Green Revolution: Curse or Blessing?*
- Handout 5, *Reading Guide: "Green Revolution: Curse or Blessing"?*
- Handout 6, *Soil Nutrients and Fertilizer*
- Handout 7, *Reading Guide: Soil Nutrients and Fertilizer*

- Handout 8, *Crop Breeding and the Green Revolution*
- Handout 9, *Reading Guide: Crop Breeding and the Green Revolution*
- Handout 10, *Quiz*
- Handout 11, *Viewing Guide: Prabhu Pingali Video Clip*
- Projection 1, *Crop Productivity Solution*
- Projection 2, *Yield Trend Solution*
- Projection 3, *Long-Run Yield Trend*
- DVD, *clip from Prabhu Pingali, "The Green Revolution Forty Years Later: Lessons Learned and Unfinished Business." Lecture delivered at Stanford University, October 6, 2011.* Complete lecture available online; instructor may choose to show additional content or to make the entire video available to students outside of class.
- Answer Key, *Mapping Crop Productivity*
- Answer Key, *Time Trends in Crop Productivity*
- Answer Key, *Reading Guide: Green Revolution: Curse or Blessing?*
- Answer Key, *Reading Guide: Soil Nutrients and Fertilizer*
- Answer Key, *Reading Guide: Crop Breeding and the Green Revolution*
- Answer Key, *Quiz*
- Answer Key, *Viewing Guide: Prabhu Pingali Video Clip*
- Reference Material, *Lecture Summary: African Agricultural R&D and Productivity Growth in a Global Setting*

Equipment

- Whiteboard or chalkboard
- Projector and dry-erase marker
- World map or atlas
- Video projector

Teacher Preparation

- Review all handouts and make the correct number of copies (one per student unless otherwise indicated).
- Review the projections and copy or scan them for display on an overhead or computer projector.
- Prior to Day One, Day Two, and Day Three, set up and test projector.
- Prior to Day Four, set up and test video projector.
- Prior to Day Four, watch the video clip and review the viewing guide and answer key. Recommended: Watch the Pingali lecture in its entirety to develop a complete understanding of the context for the clip. Refer to the Reference Material, *Lecture Summary: "African Agricultural R&D and Productivity Growth in a Global Setting,"* for additional background and analysis.
- Optional: Instructors may wish to consult the following sources for additional background information on crop productivity and the Green Revolution

- o The Consultative Group on Agricultural Research: www.cgiar.org. The CGIAR is the umbrella organization for 15 international agricultural research centers.
  - Visit the "Research and Impact" page and select "Areas of Research" for background and productivity statistics on a range of global food staples.
  - Search the site for "Green Revolution" to access a range of articles and pages related to the agricultural revolution of the 1960s, '70s, and '80s.
- o The United Nations Food and Agriculture Organization Statistics page: faostat.fao.org. Click on "Production" at the top of the page for interactive charts of crop production by country and year.

Time

The complete lesson requires at least four 50-minute class periods. Suggestions for extending or shortening the lesson are provided in the *Extensions and Excerpts* section, on page 58.

Procedures Before Day One

Explain to students that they will spend the next several days learning about one major determinant of global food security: agricultural productivity. Distribute one copy of Handout 1, *Crop Productivity*, to each student, and ask students to read the crop information on the handout before the next class period. Students should record first guesses at the productivity rankings on the final sheet; they will spend time refining their rankings in class.

Day One

1. (20 minutes) Divide the class into groups of two or three students, and ask students to take out their copies of Handout 1. Give the groups about 15 minutes to discuss their crop productivity rankings. Each group member should present his or her preliminary rankings; when every member has had a chance to defend his or her choices, the group as a whole should agree on a final ordering for all three lists.
2. (10 minutes) Display Projection 1, *Crop Productivity Solution*, and ask students to self-correct their work. Lead a brief class discussion of the exercise, asking students to respond to the following questions:
   - Which crop did your group rank highest and lowest for production and area harvested? Why?
   - How did you calculate the yield of each crop?
   - Did you change any of your production or area rankings after calculating the yields? Why?
   - Which, if any, of the correct rankings surprised you and why?
3. (15–20 minutes) Distribute one copy of Handout 2, *Mapping Crop Productivity*, to each student. Give students the remainder of the period to complete the mapping portion of the exercise; make a world map or atlas available for students' reference in locating countries.

Students may work in pairs or small groups if they wish.

4. At the end of the period, ask students to complete the Handout 2 exercise and questions as homework.

Day Two

1. (10 minutes) Ask students to take out Handout 2. Lead the class in reviewing the answers to the handout questions:
   a. Call on four students (one per crop) to quickly review the answers to question 1. Correct student work as necessary, using the answer key as a guide.
   b. Call on one or two other students to review the regional trends in overall productivity (questions 3 and 4).
   c. On a whiteboard or chalkboard, write two headings: "Crops" and "Countries/Regions." Invite students to share their responses to questions 2 and 5, listing factors under the appropriate heading on the board. Continue gathering student responses until students run out of nonduplicate factors.
   d. Ask students to comment on question 6 and to point out any factors on the board that might affect hunger and poverty in addition to crop productivity.
2. (10 minutes) Distribute one copy of Handout 3, *Time Trends in Crop Productivity,* to each student. Ask students to work in pairs to complete the first part of the exercise (sketching yield curves and answering questions 1–4 on the handout; students should go on to questions 5 and 6 if they finish early).
3. (10 minutes) After all the pairs have completed their yield curve sketches, display Projection 2, *Yield Trend Solutions*, on an overhead projector. Invite volunteers (or call on students at random) to sketch the yield curves for each crop on the solution projection with a dry-erase marker (if using a computer projection, ask students to sketch the complete graph with the yield curve on the board). Correct student work as necessary and review the relationship between production, area, and yield.
4. (5 minutes) Referring to the completed production, area, and yield graphs on the projection, briefly review the answers to questions 1–4 on the handout (use the answer key as a guide). Call students' attention to the dramatic increase in maize production between 1980 and 2009, and ask them to begin the second part of the exercise, which focuses on regional trends in maize yields during this period.
5. (15 minutes) Give students the remainder of the period to study the maize yields graph and work on the questions 5–13 on Handout 3 with a partner. Ask students to complete the exercise for homework.

Day Three

1. (10 minutes) Ask students to take out their completed copies of Handout 3. Lead a brief class discussion on questions 9 and 10:
   a. Ask students to volunteer their answers to question 9. Correct student answers as necessary, and highlight the following points:

- As crop yields were increasing during the 1980–2010 period, hunger and poverty were decreasing.
- Regions that experienced the fastest declines in poverty (e.g., Asia and South America) also experienced rapid increases in crop yields.
- Africa made little progress on either poverty or agricultural productivity in the 1980–2010 period.

b. Ask a few students to suggest reasons that a country or region might experience lower-than-average yield increases (question 10). Highlight factors that also affect hunger and poverty (see the Answer Key for examples and suggestions).

c. Ask students to respond to the following question: Why might agricultural productivity affect hunger and poverty? Possible responses include:
   - Higher yields result in greater food availability, higher farmer incomes, and lower food prices.
   - More efficient production methods reduce agriculture's demand for land and labor—farm families may be able to send a child to school or increase income by seeking off-farm employment.

Collect Handouts 1, 2, and 3 for evaluation at the end of the discussion.

2. (5 minutes) Display Projection 3, *Long-Run Yield Trend*. Ask students to volunteer answers to the three questions on the projection. Emphasize that the yield increases that students observed in the last exercise began with major changes in production practices in the 1960s; explain to students that they will spend the next two class periods learning about some of those changes, which are often referred to collectively as the Green Revolution.
3. (30 minutes) Distribute one copy each of Handouts 4 and 5, *Green Revolution: Curse or Blessing?* and *Reading Guide: Green Revolution: Curse or Blessing?*, to each student. Instruct students to spend the remainder of the period reading the brief and completing the reading guide. Students should take 10–15 minutes to read through the brief once on their own, and then discuss the questions and answers with a partner.
4. (5 minutes) At the end of the period, distribute one copy of Handout 6, *Soil Nutrients and Fertilizer,* to half the class; distribute one copy of Handout 8, *Crop Breeding and the Green Revolution,* to the other half of the class. Also distribute one copy each of Handout 7, *Reading Guide: Soil Nutrients and Fertilizer,* and Handout 9, *Reading Guide: Crop Breeding and the Green Revolution*, to each student (each student receives one reading assignment and reading guides for both assignments). Explain that students should read their assigned reading and complete the associated reading guide for homework. They will work with a partner to complete the other reading guide during the next class period.

Day Four

1. (15 minutes) Ask students to sit in pairs and to take out Handouts 4–9 (each student will have only one of Handouts 6 and 8; students should work with a partner who was assigned the opposite reading). Instruct students to complete the following tasks:
   a. Review the answers to Handout 5, discussing and resolving any questions or discrepancies (5 minutes);
   b. Take turns presenting a brief summary of their homework reading (Handout 6 or 8), explaining the material carefully so that their partner can complete the associated reading guide (5 minutes each).

   When all students have completed these steps, collect Handouts 4–9 for evaluation. Ask students to write their name and their partner's name on each handout.
2. (10 minutes) Distribute one copy of Handout 10, *Quiz,* to each student. Give students about 10 minutes to work, and then collect quizzes for evaluation.
3. (15 minutes) Explain to students that they will now watch a video clip related to the effects of the Green Revolution in India. The clip is from a lecture by a leading agricultural scientist, delivered at Stanford University in 2011.
   a. (5 minutes) Distribute one copy of Handout 11, *Viewing Guide: Prabhu Pingali Video Clip,* to each student. Give students about five minutes to review the information and questions on the viewing guide.
   b. (10 minutes) Show the video clip (7:00–15:25).
4. (10 minutes) Lead a class discussion on the video clip:
   a. Begin by asking students to read off any unfamiliar vocabulary terms in their notes. Help the class define these terms.
   b. Call on students to provide answers to the questions on the Viewing Guide. Use the Answer Key to correct student work and to provide additional extensions and commentary on the questions.
   c. Conclude by asking students to raise other questions about the lecture clip. Ask students what questions they would ask the speaker in a Q&A session, if they had the opportunity.
5. At the end of the class period, collect Handout 11 and any additional note sheets for evaluation.

Extensions and Excerpts

Extensions: This lesson does not include formal extension options. Instructors may consider having advanced students watch additional clips from the Pingali lecture (available online), read and analyze the lecture summary (*Reference Material*), or perform additional independent research using the resources provided in the *Teacher Preparation* section.

Excerpts: Instructors with less time to devote should consider the following strategies:

- Have students complete any one of the crop productivity exercises (Handouts 1–3) in a single class period.

- Teach the lesson through the first part of Day Three, covering all the crop productivity exercises but omitting the Green Revolution material.
- Teach a minilesson on the Green Revolution in two class periods, starting on Day Three after the conclusion of the crop productivity exercises and continuing through the end of the lesson.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess student work on Handout 1, *Crop Productivity Exercise*, based on
  - o the student's demonstrated ability to correctly derive yields from production and area data;
  - o accuracy of the student's final rankings (students should have self-corrected their work during the class discussion);
  - o the student's contributions to the group discussion and group rankings, including ability to logically defend their own rankings and willingness to consider other students' ideas; and
  - o the level of detail, creativity, and logical insight in the student's responses to the group discussion questions.
- Assess student work on Handout 2, *Mapping Crop Productivity Exercise,* based on
  - o accuracy and neatness of the student's crop productivity maps (students should follow directions in the exercise, using a different color for each crop and creating a clear legend showing their color scheme);
  - o accuracy of the student's entries in the yield ranking table (Question 1);
  - o the level of detail, creativity, and logical insight in the student's responses to the exercise questions (consider whether student answers mention key points included on the *Answer Key*); and
  - o the level of detail, creativity, and logical insight in the student's contributions to group review and discussion.
- Assess student work on Handout 3, *Time Trends in Crop Productivity Exercise,* based on
  - o accuracy and neatness of the student's yield curve sketches. Sketches need not match the answer key exactly, but should show the correct trend (increasing, decreasing, or constant in appropriate regions) and should end at the approximate 2009 value (taken from Handout 1);
  - o accuracy of the student's responses to the handout questions, (use the *Answer Key* as a guide);
  - o the level of detail, creativity, and logical insight in the student's responses to open-ended handout questions; and
  - o accuracy and clarity of students' contributions to group review of the yield curve sketches.

- Assess student work on Handouts 5, 7, and 9, *Reading Guide: Green Revolution: Curse or Blessing?*, *Reading Guide: Soil Nutrients and Fertilizer*, and *Crop Breeding and the Green Revolution* based on
  - o accuracy of the student's responses to the questions in each reading guide (use the answer keys as a guide);
  - o the level of detail, creativity, and logical insight in the student's responses to the reading guide questions; and
  - o the student's ability to formulate and interpret summaries of reading content, as demonstrated by each partner's work on the reading guide for the handout (*Soil Nutrients and Fertilizer* or *Crop Breeding and the Green Revolution*) that they did *not* complete for homework.
- Assess student work on the *Quiz* based on
  - o accuracy of the student's responses (use the *Answer Key* as a guide); and
  - o the level of detail, creativity, and logical insight in the student's responses to more open-ended questions (i.e., questions 5–7).
- Assess student work on Handout 11, *Viewing Guide: Prabhu Pingali Video Clip*, based on
  - o accuracy of the student's responses (use the answer key as a guide);
  - o the student's attention to unfamiliar vocabulary and demonstrated commitment to seeking accurate definitions during class discussion;
  - o the student's demonstrated ability to formulate creative, appropriate questions for the speaker; and
  - o neatness, organization, and thoroughness of students' notes, demonstrating ability to take useful notes while absorbing the video material.
- Assess students' participation in group work and class discussion throughout the lesson based on
  - o accuracy and appropriateness of contributions;
  - o clear and succinct statement of comments, questions, and answers;
  - o attention to other students' questions and ideas;
  - o ability to follow and promote lively, productive discussion;
  - o open-mindedness and respect for other students' backgrounds and opinions;
  - o willingness and ability to incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
  - o willingness and ability to express confusion and request clarification from other students and the instructor.

Crop Productivity

Information on this handout adapted from the Consultative Group on International Agricultural Research, http://www.cgiar.org/our-research/crop-factsheets/.

The following pages present basic information on eight food crops. Each of these eight crops accounts for a large share of calorie production and consumption, either globally or in certain food-insecure developing regions. Thus, these crops are particularly important from the perspective of global food security.

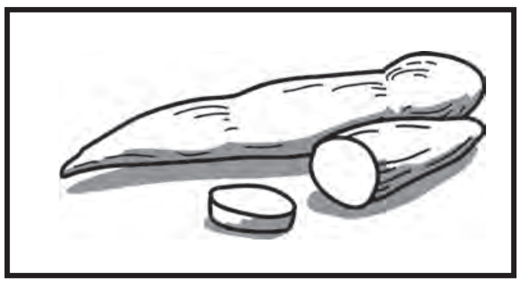
In this exercise, you will learn where these eight crops are grown and how they are used. You will then compare their global performance on three common measures of agricultural productivity: quantity produced, area harvested, and yield. Read the information on each crop carefully, then read the brief definitions of the three productivity measures on the exercise handout. Use the crop information, your own prior knowledge, and your best intuition to fill in the rankings below the productivity definitions with the names of the eight crops. Note: Rank the crops by production and area first, and then calculate the average global yields (read the definitions carefully to understand the necessary calculations). Make sure you agree with the yield ranking that results from your production and area rankings—you may wish to change your original rankings after calculating the yields!

Barley

Barley is cultivated throughout the world, but it is a particularly important food source for poor farmers in North Africa, the Middle East, and South Asia. Barley exhibits high genetic diversity as a result of its history of cultivation under a wide range of environmental conditions. Barley plants have a higher tolerance for drought and salinity (high concentrations of salt in water and soil) than many other cereals, and they are often grown in especially harsh environments.

Barley is high in carbohydrates and is thus a good source of energy for both animals and people. The straw of the barley plant is often used as an animal feed, and barley flour can be used in bread to supplement wheat flour. Barley is also widely used to produce malt, a sweetener marketed as a syrup or powder.

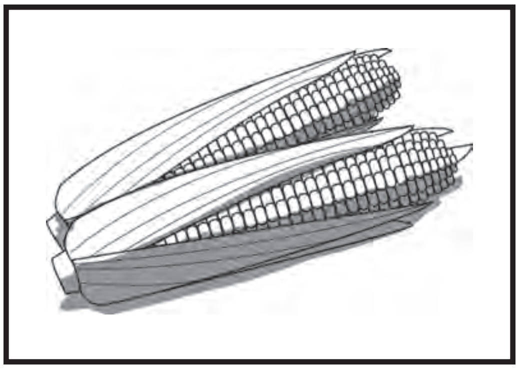
Cassava



Cassava (sometimes called yucca or manioc) is a hardy shrub cultivated primarily in developing Africa and, to a slightly lesser extent, in Asia and Latin America. Cassava plants require little maintenance and grow well in dry, infertile soils. The cassava plant produces a starchy, tuberous root, similar to a yam or sweet potato, which can be left in the ground for many years and harvested at need.

Cassava roots are a critical source of calories for subsistence farmers in many African countries; the leaves of the plant, which contain protein and vitamins A and B, are also widely consumed in developing Africa. In other regions, the cassava root is used as a livestock feed and to produce binding agents, paper, and textiles.

Corn (Maize)



Corn, or maize, is a versatile grain crop that is cultivated throughout the world in a wide range of soils and climates. Like barley, corn exhibits tremendous genetic diversity (manifested in the range of colors, sizes, and shapes represented among the different varieties of the crop). This diversity is a product of a long history of adaptation to vastly different growing environments.

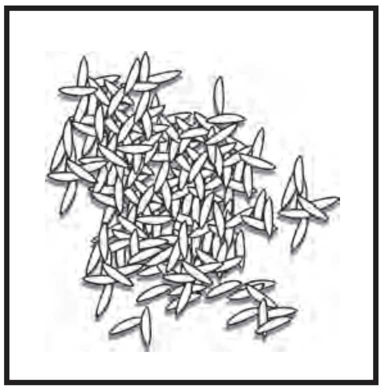
Corn is an important global food source, accounting for a large share of calorie consumption in some developing regions—particularly Africa and Latin America. Corn is also used as a feed grain for livestock and for industrial purposes (including biofuel production) in some countries.

Millet

The term *millet* refers to a wide variety of small-seeded grasses cultivated primarily in Asia and increasingly in Africa. Millet plants have physical properties similar to those of maize and sorghum, but they can grow in much harsher soils and climates. Millet plants can withstand environmental challenges ranging from extreme drought, to flash floods, to insect infestation. They grow rapidly when conditions are favorable, and the crop can be stored for long periods without damage or spoilage.

Millet is consumed as a staple cereal and is a key source of calories in many of the world's poorest countries. Millet grains contain nutrients that are absent from many other staple foods, including calcium, iron, manganese, and certain amino acids. In some areas, millet straw is also used as a livestock feed, building material, and fuel source.

Rice

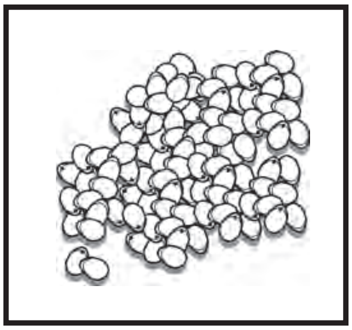


Rice is cultivated in more than 100 countries worldwide, but the majority of the world rice crop is produced and consumed in Asia. Many of the world's rice farms are located in lowland areas that are prone to sudden, uncontrolled flooding; rice plants grown in these areas have adapted to survive flooding episodes that leave them submerged beneath several meters of water for weeks or months at a time.

Rice accounts for up to 80% of the calories consumed in developing Asia, and it is also an important food source in Africa and Latin America. In addition to providing a modest amount of protein, rice grains contain several important vitamins and minerals, such as thiamine, a B vitamin.

Sorghum

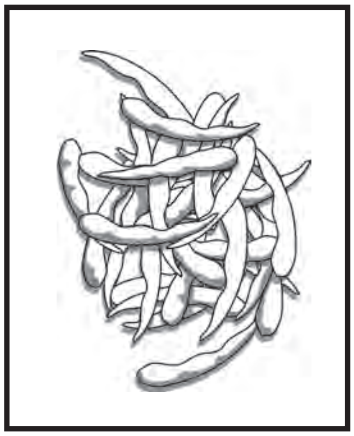
Sorghum is widely cultivated in the developing nations of Africa, South Asia, and Central America, as well as in developed nations such as Australia and the United States. Historians believe that sorghum originated in North Africa, where a large variety of both wild and cultivated species are still found today. The crop is particularly well adapted to drought, and it is often grown in regions too hot and dry to support maize.



In the developing world, sorghum is grown primarily for human consumption. The grain is usually steamed or cooked as a porridge, or may be brewed into beverages. Some countries, primarily Nigeria, have also begun to develop industrial uses for sorghum. In developed countries, the crop is primarily used as an animal feed.

Soybeans

The soybean is a legume cultivated primarily in Asia, North America, and South America (particularly Brazil). Soybeans have a high protein and fat content, making them an important inexpensive source of protein and oil in the developing world. A by-product of soybean oil production called soybean cake is also used as a high-protein animal feed in some countries.



Unlike cereal crops, soybeans and other legumes obtain nitrogen (a critical nutrient for plant development) from the atmosphere rather than from the soil. By transferring nitrogen from the air to the soil, these crops can help to restore the nutrient balance in soils that have been depleted of nitrogen by cereal crops. Soybeans can thus act as an inexpensive, readily accessible substitute for nitrogen fertilizers in developing regions.

Wheat

Wheat is widely cultivated throughout Asia, Europe, Africa, and North America; historians estimate that humans have grown wheat for more than 6,000 years. Unlike most other cereals, wheat contains a high quantity of gluten, a protein that gives leavened bread its structure and texture. Because of its high protein content, wheat is an important contributor to calorie and protein consumption in the developing world.

Crop researchers have catalogued more than 30,000 varieties of wheat. Of the handful of widely cultivated varieties, most are consumed primarily as human food in breads and other baked goods. Small quantities of wheat are also used to produce industrial products such as starch, paste, and alcohol. Surplus wheat and wheat by-products are used as livestock feed.

Production

The total quantity of the crop harvested in a given year, usually measured in kilograms or metric tons (one metric ton = 1,000 kg)

Million metric tons, 2009–2010:

829 ____________________

649 ____________________

451 ____________________

264 ____________________

234 ____________________

124 ____________________

66 ____________________

34 ____________________

Area Harvested

The total land area used to produce the crop, usually measured in acres or hectares (one hectare = 2.47 acres)

Million hectares, 2009–2010:

223 ____________________

163 ____________________

157 ____________________

103 ____________________

51 ____________________

41 ____________________

34 ____________________

19 ____________________

Yield

The amount of crop harvest output per some given quantity of input—usually land—e.g., metric tons of output per hectares of area harvested. Yield may also refer to inputs other than land, e.g., metric tons of crop output per kilogram of fertilizer or per gallon of water.

Metric tons per hectare, 2009–2010:

_____ ____________________

_____ ____________________

_____ ____________________

_____ ____________________

_____ ____________________

_____ ____________________

_____ ____________________

_____ ____________________

Mapping Crop Productivity

In the last exercise, you learned about eight food crops that play important roles in global food security. This exercise focuses on four of those crops: cassava, maize, rice, and sorghum.

On the following pages, you will find detailed information on the production, area harvested, and yield of each of these crops in the 10 countries that produce the greatest quantity of the crop (these countries have the highest *production* but not necessarily the highest *area harvested* or *yield* out of all the countries of the world). You will also find a blank world map. Carry out the following steps for each of the four crops:

1. Locate the top 10 producing countries on the map.
2. Write the *yield* of the crop in each of the top 10 countries inside or adjacent to its borders. Use a different color pen or pencil for each crop; create a legend at the top of your map to document your color-coding scheme.

Once you have mapped all the yield numbers for each of the four crops, answer the questions below:

1. Complete the table with the highest and lowest yields (among the top 10 producing countries) for each crop:

	Lowest top 10 yield	Top 10 country with lowest yield	Highest top 10 yield	Top 10 country with highest yield	Lowest yield is ___% of highest yield
Cassava					
Maize					
Rice					
Sorghum					

2. What factors might account for the differences in yields between crops?

3. Do the countries and regions with the highest yields also tend to plant more area and harvest greater quantities? Why do you think this is or is not the case?

4. Do any countries or regions have unusually high yields across all four crops? Do any countries or regions have unusually low yields? Describe any trends you see.

5. Brainstorm a list of factors that might account for the differences in yields between countries and regions. Consider economic, political, and social factors in addition to environmental constraints; try to think of at least 10 factors.

6. How do national and regional differences in crop yields compare with national and regional differences in poverty and hunger rates?

Top 10 global cassava producers, 2009			
Country	**Production, metric tons**	**Area harvested, hectares**	**Yield, metric tons per hectare**
Nigeria	36,804,300	3,126,510	11.77
Thailand	30,088,000	1,326,740	22.68
Brazil	24,404,000	1,760,580	13.86
Indonesia	22,039,100	1,175,670	18.75
Democratic Republic of the Congo	15,000,000	1,850,000	8.11
Angola	12,827,600	994,422	12.90
Ghana	12,230,600	885,800	13.81
India	9,623,000	280,000	34.37
Vietnam	8,556,900	508,800	16.82
United Republic of Tanzania	5,916,000	1,081,380	5.47

Top 10 global maize producers, 2009			
Country	**Production, metric tons**	**Area harvested, hectares**	**Yield, metric tons per hectare**
United States of America	333,011,000	32,209,300	10.34
China	164,107,560	31,203,727	5.26
Brazil	51,232,400	13,791,200	3.71
Mexico	20,142,800	6,223,050	3.24
Indonesia	17,629,700	4,160,660	4.24
India	16,680,000	8,330,000	2.00
France	15,288,200	1,679,870	9.10
Argentina	13,121,400	2,337,180	5.61
South Africa	12,050,000	2,427,500	4.96
Ukraine	10,486,300	2,089,100	5.02

Source: UN Food and Agriculture Organization (faostat.fao.org)

Top 10 global rice producers, 2009			
Country	**Production, metric tons**	**Area harvested, hectares**	**Yield, metric tons per hectare**
China	196,681,170	29,881,590	6.58
India	133,700,000	41,850,000	3.19
Indonesia	64,398,900	12,883,600	5.00
Bangladesh	47,724,000	11,354,000	4.20
Vietnam	38,895,500	7,440,100	5.23
Myanmar	32,682,000	8,000,000	4.09
Thailand	31,462,900	10,963,100	2.87
Philippines	16,266,400	4,532,300	3.59
Brazil	12,651,800	2,872,040	4.41
Japan	10,592,500	1,624,000	6.52

Top 10 global sorghum producers, 2009			
Country	**Production, metric tons**	**Area harvested, hectares**	**Yield, metric tons per hectare**
United States of America	9,728,220	2,233,890	4.35
India	7,250,000	7,530,000	0.96
Mexico	6,108,090	1,690,520	3.61
Nigeria	5,270,790	4,736,730	1.11
Sudan	4,192,000	6,652,500	0.63
Ethiopia	2,971,270	1,618,680	1.84
Australia	2,691,790	766,986	3.51
Brazil	1,853,930	793,027	2.34
Argentina	1,805,220	456,510	3.95
China	1,677,319	559,542	3.00

Source: UN Food and Agriculture Organization (faostat.fao.org)

Time Trends in Crop Productivity

In the last exercise, you learned how yields of cassava, maize, rice, and sorghum vary between the world's countries and regions. You will now investigate how production and yields of those crops have changed over time.

This handout contains five charts. The first four charts show global changes in production of cassava, maize, rice, and sorghum between 1980 and 2009. On each chart, the dashed line represents total area harvested, and the solid line represents total quantity produced. At each point along the *x*-axis (i.e., in each year) both measures of productivity are expressed in terms of the **percentage increase from 1980 levels**. Thus, the point (1980, 0) lies on both lines on every chart. An upward trend indicates steady increases from 1980; when a line crosses the 100% mark (as in the case of maize production around 2007), the productivity measure has doubled from its 1980 value.

The right-hand axis of each of these first four charts has been labeled with the correct range of yield values for the crop in the 1980–2009 period. By studying the production and area trends, you should be able to sketch the approximate trends in yields. Review the definitions of production, area harvested, and yield in the Handout 1, *Crop Productivity*, if you need a refresher on the relationship between these three measures. Do not worry about getting the yield value exactly right at each point on the curve; instead, focus on determining whether yield must be increasing, decreasing, or stable in light of the trends in production and area.

Once you have finished sketching the yield curves, answer the following questions:

1. Which crop experienced the greatest percentage increase in production between 1980 and 2009?

2. Which crop experienced the least increase in production?

3. Which crop experienced the greatest increase in yield?

4. Which crop experienced the least increase in yield?

5. In general (across all four crops), how much did the area harvested change between 1980 and 2009? Compare and contrast the change in area with the changes in production and yield, and offer an explanation for the differences.

6. Why do you think that production and yields increased more for some crops than for others?

Finally, examine the last chart in the handout, which shows changes in regional maize yields between 1980 and 2005. Note that the yield in each year is expressed in the same way that production and area were in the previous four charts, i.e., as a percentage change from the 1980 yield. Answer the following questions based on the maize yields chart:

7. In which region did maize yields increase the most between 1980 and 2009?

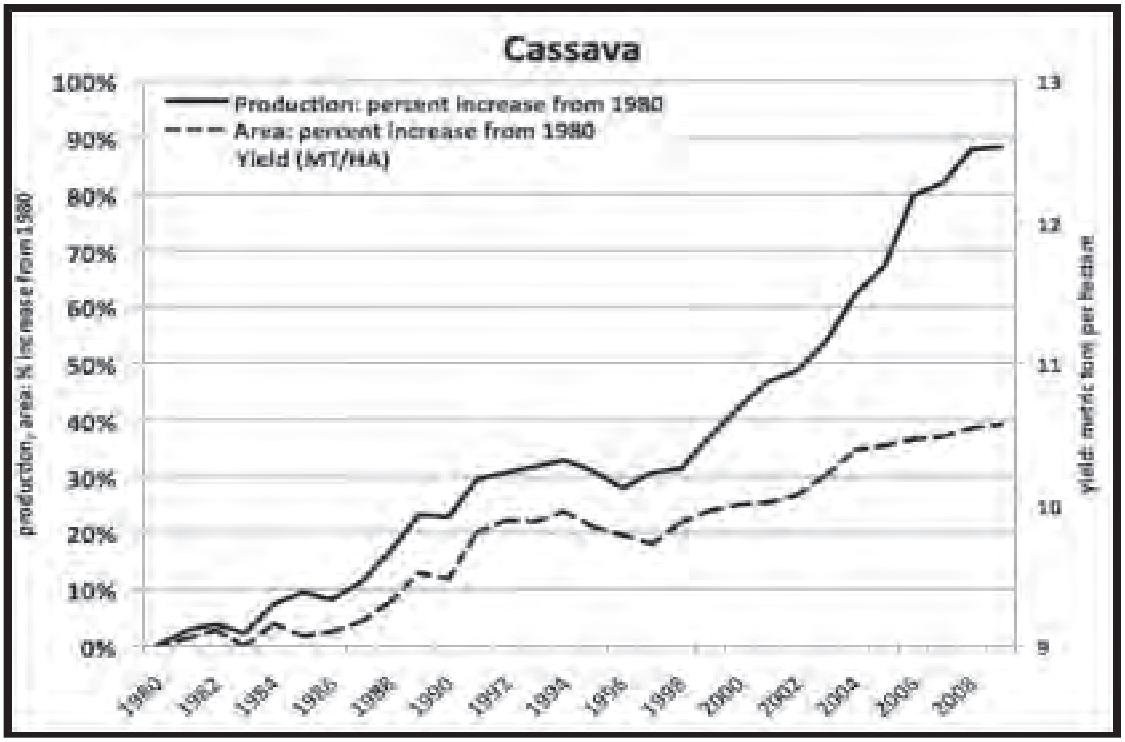
8. In which region did maize yields increase the least?

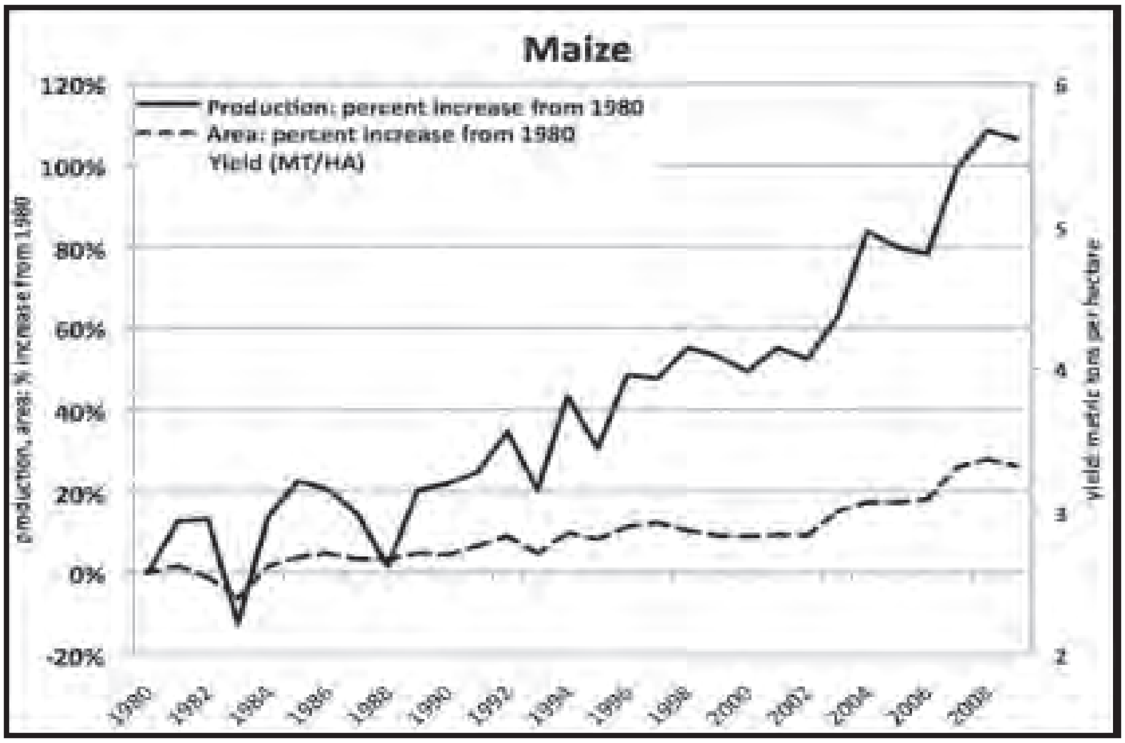
9. How do these regional time trends in maize yields compare with time trends in hunger and poverty?

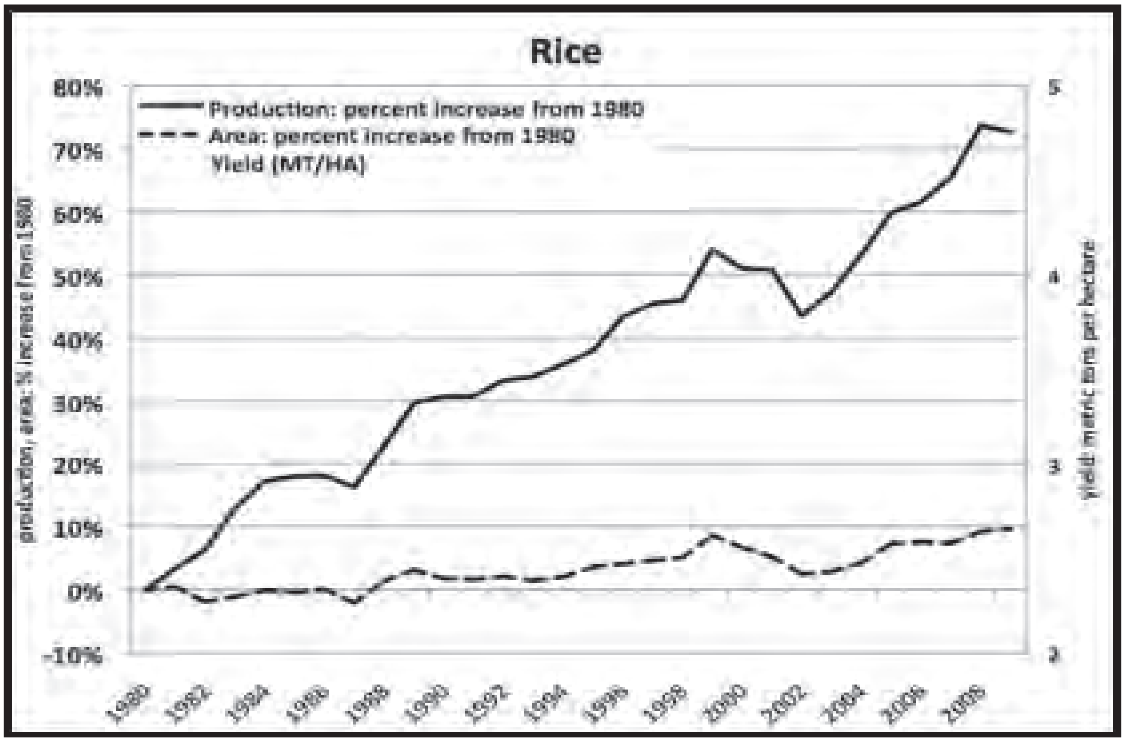
10. Offer several reasons that a country or region might experience lower-than-average yield increases.

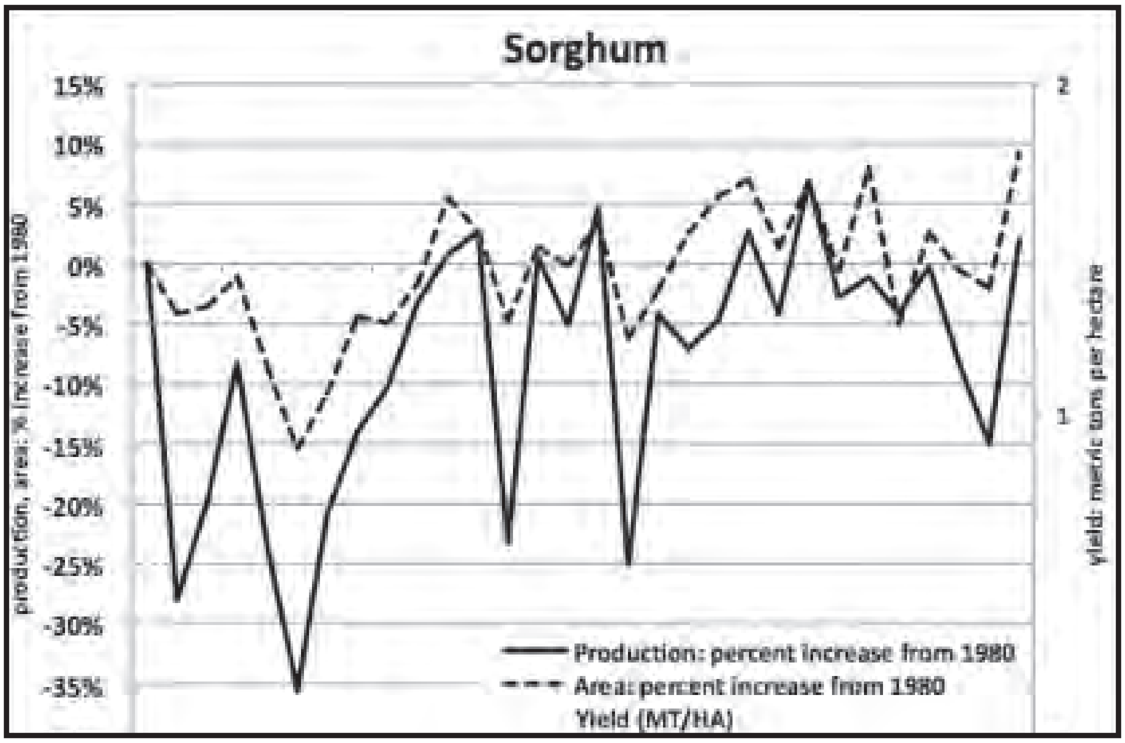
11. Maize is a good crop to use as a reference when making general comparisons of agricultural productivity between regions. Why is this the case?

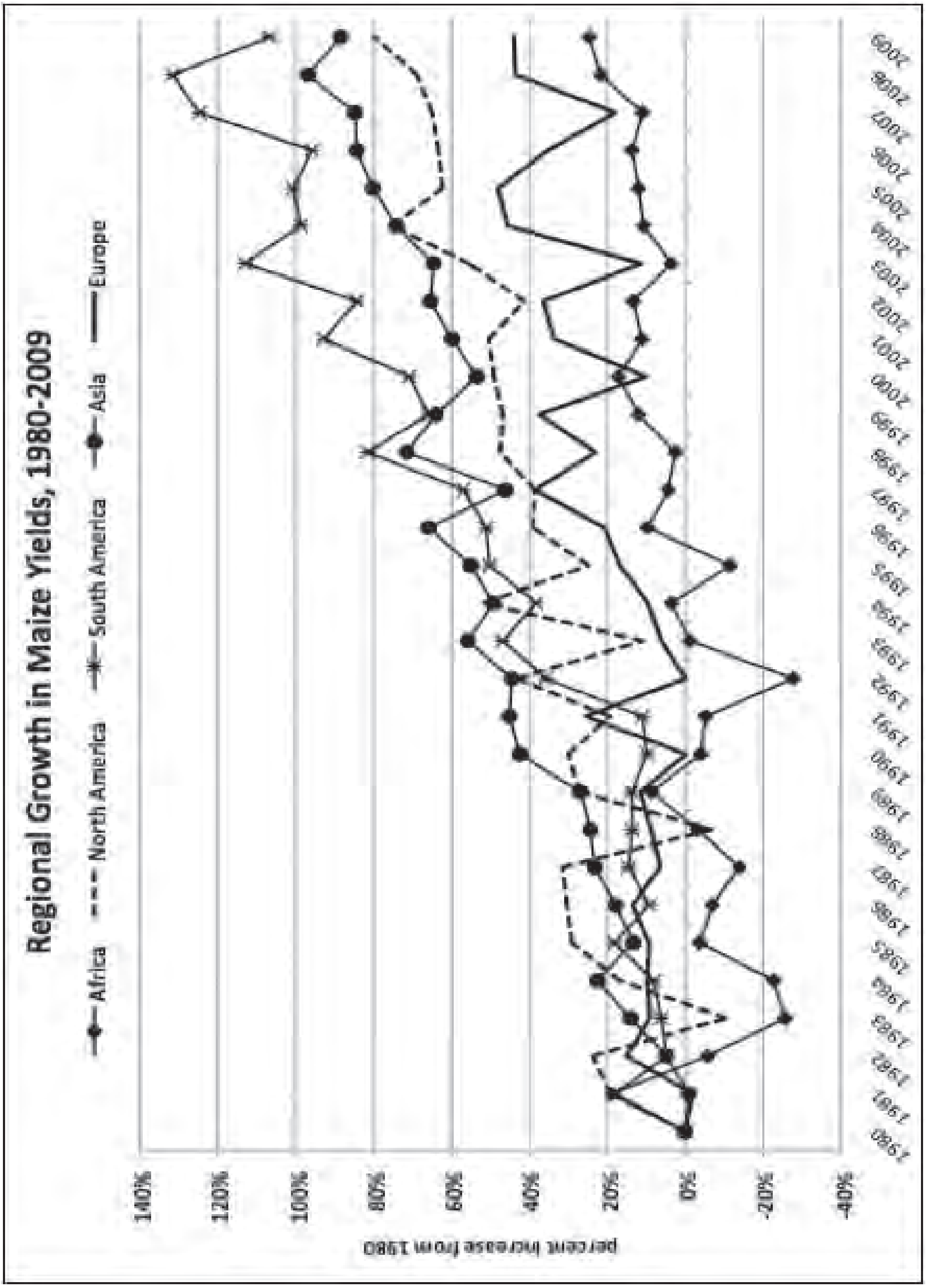
Based on the trends in global production and area harvested for each crop, sketch the correct trend in the crop yield. An accurate range in yield values is given on the right-hand axis; you may find it helpful to refer to the Crop Productivity exercise for the exact 2009 yield value, which gives the height of the yield line at its rightmost end. Note that while production and area are expressed in percent increase from 1980, yield is expressed (as usual) in metric tons per hectare.






Rice
Production: percent increase from 1980
Area: percent increase from 1980
Yield (MT/HA)
production, area: % increase from 1980
yield: metric tons per hectare
80%
70%
60%
50%
40%
30%
20%
10%
0%
-10%
5
4
3
2
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008


Sorghum
15%
10%
5%
0%
-5%
-10%
-15%
-20%
-25%
-30%
-35%
2
1
production, area: % increase from 1980
yield: metric tons per hectare
Production: percent increase from 1980
Area: percent increase from 1980
Yield (MT/HA)



Source: UN Food and Agriculture Organization, faostat.fao.org


INTERNATIONAL FOOD
POLICY RESEARCH INSTITUTE
sustainable options for ending hunger and poverty
IFPRI
GREEN REVOLUTION
Curse or Blessing?
IR 20
NPK
NPK

Food problems have haunted mankind since time immemorial. With few technological breakthroughs to increase yields, the food needs of growing populations were historically met by expanding the cultivated area. As the most fertile land became scarce, further expansion meant bringing poorer and lower-yielding land into cultivation. By the 19th century, there was growing pessimism about the possibility of feeding ever-growing populations, as exemplified in the writings of Thomas Malthus (1766–1834). The task seemed even more daunting as advances in medicine and public health led to longer life expectancies and more children born.

In the 20th century, massive public investments in modern scientific research for agriculture led to dramatic yield breakthroughs in the industrial countries. The story of English wheat is typical. It took nearly 1,000 years for wheat yields to increase from 0.5 to 2 metric tons per hectare, but only 40 years to climb from 2 to 6 metric tons per hectare. Modern plant breeding, improved agronomy, and the development of inorganic fertilizers and modern pesticides fueled these advances. Most industrial countries achieved sustained food surpluses by the second half of the 20th century, and eliminated the threat of starvation.

These advances were much slower in reaching developing countries. The colonial powers invested little in the food production systems of these countries, and by independence, their populations were growing at historically high rates. By the mid-1960s, hunger and malnutrition were widespread, especially in Asia, which increasingly depended on food aid from rich countries. Back-to-back droughts in India during the mid-1960s made the already precarious situation worse, and a 1967 report of the U.S. President's Science Advisory Committee concluded that "the scale, severity and duration of the world food problem are so great that a massive, long-range, innovative effort unprecedented in human history will be required to master it."

In response, the Rockefeller and Ford foundations took the lead in establishing an international agricultural research system to help transfer and adapt scientific advances to the conditions in developing countries. The first investments were in research on rice and wheat, two of the most important food crops for developing countries. The breeding of improved varieties, combined with the expanded use of fertilizers, other chemical inputs, and irrigation, led to dramatic yield increases in Asia and Latin America, beginning in the late 1960s. In 1968, U.S. Agency for International Development (USAID) Administrator William S. Gaud coined the term "Green Revolution" to describe this phenomenal growth in agriculture.

To achieve higher yields for rice and wheat, scientists needed to develop plants that were more responsive to plant nutrients and that had shorter, stiffer straw to support the weight of heavier heads of grain. They also needed to develop varieties that could mature quicker and grow at any time of the year, thereby permitting farmers to grow more crops each year on the same land. New varieties also needed to be resistant to major pests and diseases, which flourish under intensive farming conditions, and to retain desirable cooking and consumption traits.

Borrowing from rice-breeding work undertaken in China, Japan, and Taiwan, the International Rice Research Institute (IRRI) in the Philippines developed semi-dwarf varieties that met most of these requirements. Similar achievements were made for wheat after Norman Borlaug (later awarded the Nobel Peace Prize for his work) crossed Japanese semi-dwarf varieties with Mexican wheats at what is now known as the International Center for Maize and Wheat Improvement (CIMMYT) in Mexico.

Although the term Green Revolution originally described developments for rice and wheat, high-yielding varieties (HYVs) have since been developed for other major food crops important to developing countries, including sorghum, millet, maize, cassava, and beans. Moreover, a full-fledged system of international agricultural research centers now works on many aspects of developing-country agriculture (the Future Harvest Centers that make up the Consultative Group on International Agricultural Research).

IMPACTS ON AGRICULTURAL PRODUCTION

The adoption of HYVs occurred quickly. By 1970, about 20 percent of the wheat area and 30 percent of the rice area in developing countries were planted to HYVs, and by 1990, the share had increased to about 70 percent for both crops. Yields of rice and wheat virtually doubled. Higher yields and profitability also led farmers to increase the area of rice and wheat they grew at the expense of other crops. And with faster-growing varieties and irrigation, they grew more crops on their land each year. These changes more than doubled cereal production in Asia between 1970 and 1995, while population

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increased by 60 percent. Instead of widespread famine, cereal and calorie availability per person increased by nearly 30 percent, and wheat and rice became cheaper.

Latin America experienced significant gains as well, but the impact in Sub-Saharan Africa was much more modest. Poor infrastructure, high transport costs, limited investment in irrigation, and pricing and marketing policies that penalized farmers made the Green Revolution technologies too expensive or inappropriate for much of Africa.

SOCIAL IMPACTS

The Green Revolution led to sizable increases in returns to land, and hence raised farmers' incomes. Moreover, with greater income to spend, new needs for farm inputs, and milling and marketing services, farm families led a general increase in demand for goods and services. This stimulated the rural nonfarm economy, which in turn grew and generated significant new income and employment of its own. Real per capita incomes almost doubled in Asia between 1970 and 1995, and poverty declined from nearly three out of every five Asians in 1975 to less than one in three by 1995. The absolute number of poor people fell from 1.15 billion in 1975 to 825 million in 1995 despite a 60 percent increase in population. In India, the percentage of the rural population living below the poverty line fluctuated between 50 and 65 percent before the mid-1960s but then declined steadily to about one-third of the rural population by 1993. Research studies show that much of this steady decline in poverty is attributable to agricultural growth and associated declines in food prices.

The Green Revolution also contributed to better nutrition by raising incomes and reducing prices, which permitted people to consume more calories and a more diversified diet. Big increases occurred in per capita consumption of vegetable oils, fruits, vegetables, and livestock products in Asia.

PROBLEMS WITH THE GREEN REVOLUTION

A revolution of this magnitude was bound to create some problems of its own. Critics charged that the Green Revolution resulted in environmental degradation and increased income inequality, inequitable asset distribution, and worsened absolute poverty. Some of these criticisms are valid and have been or still need to be addressed. But there is a tendency today to overstate the problems and to ignore the appropriate counterfactual situation: what would have been the magnitude of hunger and poverty without the yield increases of the Green Revolution and with the same population growth?

The Green Revolution in Asia stimulated a large body of empirical literature on how agricultural technological change affects poor farmers. Critics of the Green Revolution argued that owners of large farms were the main adopters of the new technologies because of their better access to irrigation water, fertilizers, seeds, and credit. Small farmers were either unaffected or harmed because the Green Revolution resulted in lower product prices, higher input prices, and efforts by landlords to increase rents or force tenants off the land. Critics also argued that the Green Revolution encouraged unnecessary mechanization, thereby pushing down rural wages and employment. Although a number of village and household studies conducted soon after the release of Green Revolution technologies lent some support to early critics, more recent evidence shows mixed outcomes. Small farmers did lag behind large farmers in adopting Green Revolution technologies, yet many of them eventually did so. Many of these small-farm adopters benefited from increased production, greater employment opportunities, and higher wages in the agricultural and nonfarm sectors. Moreover, most smallholders were able to keep their land and experienced significant increases in total production. In some cases, small farmers and landless laborers actually ended up gaining proportionally more income than larger farmers, resulting in a net improvement in the distribution of village income.

Development practitioners now have a better understanding of the conditions under which the Green Revolution and similar yield-enhancing technologies are likely to have equitable benefits among farmers. These conditions include: (1) a scale-neutral technology package that can be profitably adopted on farms of all sizes; (2) an equitable distribution of land with secure ownership or tenancy rights; (3) efficient input, credit, and product markets so that farms of all sizes have access to modern farm inputs and information and are able to receive similar prices for their products; and (4) policies that do not discriminate against small farms and landless laborers (for instance, no subsidies on mechanization and no scale biases in agricultural research and extension). These conditions are not easy to meet. Typically, governments must make a concerted effort to ensure that small farmers have fair access to land, knowledge, and modern inputs.

Another shortcoming of the Green Revolution was that it spread only in irrigated and high-potential rainfed areas, and many villages or regions without access to sufficient water were left out. Although evidence suggests that even in these cases villagers obtained important indirect benefits through increased employment and migration opportunities and cheaper food, the benefits were rarely sufficient to prevent further widening of income gaps. In India, for example, poverty in many low-potential rainfed areas has improved little even while irrigated and high-potential rainfed areas have progressed. Regional inequalities have worsened in China as well.

The Green Revolution has also been widely criticized for causing environmental damage. Excessive and inappropriate use of fertilizers and pesticides has polluted waterways, poisoned agricultural workers, and killed beneficial insects and other wildlife. Irrigation practices have led to salt build-up and eventual abandonment of some of the best farming lands. Groundwater levels are retreating in areas where more water is being pumped for irrigation than can be replenished by the rains. And heavy dependence on a few major cereal varieties has led to loss of biodiversity on farms. Some of these outcomes were inevitable as millions of largely illiterate farmers began to use modern inputs for the first time, but inadequate extension and training, an absence of effective regulation of water quality, and input pricing and subsidy policies that made modern inputs too cheap and encouraged excessive use also created negative environmental impacts. These problems are slowly being rectified without yield loss, and sometimes with yield increases, thanks to policy reforms and improved technologies and management practices, such as pest-resistant varieties, biological pest control, precision farming, and crop diversification.

Often ignored, however, is the positive impact of higher yields in saving huge areas of forest and other environmentally fragile lands that would otherwise have been needed for farming. In Asia cereal production doubled between 1970 and 1975, yet the total land area cultivated with cereals increased by only 4 percent.

Conclusions

Overall, the Green Revolution was a major achievement for many developing countries and gave them an unprecedented level of national food security. It represented the successful adaptation and transfer of the same scientific revolution in agriculture that the industrial countries had already appropriated for themselves. The Green Revolution also lifted large numbers of poor people out of poverty and helped many nonpoor people avoid the poverty and hunger they would have experienced had the Green Revolution not occurred. The largest benefits to the poor were mostly indirect, in the form of lower food prices, increased migration opportunities, and greater employment in the rural nonfarm economy. The direct benefits to the poor through their own on-farm adoption, greater agricultural employment, and empowerment have been more mixed and depend heavily on local socioeconomic conditions. In many cases inequalities between regions and communities that adopted Green Revolution technologies and those that did not also worsened. At the same time, the Green Revolution had many negative environmental impacts that have still to be adequately redressed.

Agricultural research remains a potent force for good in the developing world and is the key to increasing yields further to meet the continuing growth of food needs in developing countries. This need is especially urgent in Sub-Saharan Africa, which has yet to experience an agricultural revolution of its own. But simply adding to the pile of food will not be enough. The indirect benefits for the poor are likely to be weaker in the future as globalization and trade make food prices less responsive to local production and as agriculture becomes less important to the livelihoods of the poor. Policymakers will need to target the poor more precisely to ensure that poor people receive greater direct benefits from new technologies. New technologies will also need to be more environmentally sustainable. By building on the strengths of the Green Revolution while seeking to avoid its weaknesses, scientists and policymakers can take significant steps toward achieving sustainable food security for all the world's people.

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Reading Guide: "Green Revolution: Curse or Blessing?"

1. How did farmers generally achieve crop production increases in the 19th century, and how did their methods change at the beginning of the 20th century?

2. What crops and regions were the first to benefit from the Green Revolution?

3. What traits did crop breeders look for to create new high-yielding varieties?

4. How did farmers change their practices as they adopted high-yielding varieties?

5. What region was left out of the Green Revolution, and why?

6. Describe how the Green Revolution affected income, poverty, and nutrition in Asia.

7. What consequences did the Green Revolution have for small farmers and the rural poor?

8. How can governments and aid organizations ensure that agricultural development helps small farmers? Summarize the brief's suggestions in your own words.

9. What natural resource did farmers need in order to fully capitalize on the technological development of the Green Revolution?

10. List several ways in which the Green Revolution affected the natural environment.

11. What steps can help reduce the negative environmental effects of Green Revolution technologies?

12. How did the Green Revolution indirectly affect the world's poor, and why are indirect effects likely to be weaker in the future?

Soil Nutrients and Fertilizer

All plants, including agricultural crops, need a variety of nutrients to live and grow. Plants obtain some of this fuel through the well-known process of photosynthesis. Photosynthesis uses the sun's energy to convert carbon dioxide and water into various starches and sugars.

mineral nutrients—inorganic (non-carbon-based) nutrients obtained by plants through soil absorption rather than through photosynthesis

However, most plants also need at least a dozen mineral nutrients to build strong stems, roots, and leaves; produce fruit and seeds; and fuel the photosynthetic process. The most important mineral nutrients for plant growth are nitrogen (N), phosphorous (P), and potassium (K); calcium (Ca), magnesium (Mg), and sulfur (S) also play key roles. It is no coincidence that many of these nutrients also are essential for human life. For example, phosphorous, calcium, and magnesium are all major building blocks of human bone.

fallow—uncultivated; to *fallow* a piece of land means to forgo planting the land with crops for one or more seasons

fertilizer—any substance that contains a sufficient quantity of the essential plant nutrients to act as an effective soil restorative and an aid in plant growth

Mineral nutrients contain no carbon or hydrogen and thus cannot be obtained through photosynthesis. Instead, plants obtain mineral nutrients from the soil. Soil nutrient availability varies depending on soil properties such as texture and acidity. Some soil types do not contain sufficient nutrients to support rapid or healthy plant growth. Even soils that initially support vibrant growth become depleted of nutrients if subjected to many consecutive years of aggressive farming—most agricultural crops consume soil nutrients greedily, especially when farmers seed the land densely and frequently in an attempt to maximize their annual yield.

natural (organic) fertilizer—naturally occurring substances that contain high concentrations of essential plant nutrients, such as livestock manure or powdered mineral rocks.

Farmers can take various steps to correct soil nutrient deficiencies. The simplest option, of course, is to let the land lie fallow—to forgo farming an area for a few years, allowing weeds and other natural vegetation to grow and decay and giving the nutrient stock a chance to recover. But fallowing may not be an option for farmers who depend on the output from a small plot as his or her primary source of food or income. Farmers who need to restore depleted soils quickly usually apply some type of fertilizer. The term *fertilizer* refers broadly to any substance that contains a sufficient quantity of the essential plant nutrients to act as an effective soil restorative and an aid in plant growth.

leguminous plants—plants in the family *Leguminosae*. Common examples include peas, beans (including soybeans), lentils, peanuts, alfalfa, and clover

inorganic fertilizer—a chemically manufactured substitute for natural fertilizers. Inorganic fertilizers usually contain much higher nutrient concentrations than are found in naturally occurring fertilizers

Farmers have applied naturally occurring fertilizers to their crops for centuries. The simplest and most common natural fertilizer is livestock manure. Other options include composted vegetable waste and powdered mineral rocks such as rock phosphate, lime, and potassium phosphate. Some farmers can also restore soil nutrients naturally by planting crops with different nutrient requirements or growth processes. For example, leguminous plants—including most beans and peas—obtain nitrogen from the air rather than through soil. When these plants die, they release the nutrients into the soil, adding new nitrogen to the soil stock.

In some cases, however, natural fertilizers are not available or do not contain sufficient nutrient concentrations to restore dramatically depleted soils. Inorganic fertilizers are chemically manufactured substitutes for

Haber-Bosch process—a technique for synthesizing inorganic ammonia, which is a common ingredient in nitrogen-based inorganic fertilizers

eutrophication—oxygen deprivation occurring in lakes, rivers, and oceans as a result of overfertilization (often associated with fertilizer runoff from agricultural operations)

natural fertilizers. Inorganic fertilizers have extremely high nutrient concentrations—they may contain a single key nutrient (usually nitrogen, phosphorous, or potassium) in concentrations up to 100 times higher than are found in the more balanced nutrient profiles of most organic fertilizers.

The most common inorganic fertilizers are based on the nitrogen compound ammonia (NH3). Ammonia-based fertilizers contain up to 150 times the concentration of nitrogen of most natural fertilizers. During the early 20th century, German scientists Fritz Haber and Karl Bosch developed a technique, now known as the Haber-Bosch process, for synthesizing inorganic ammonia. Their energy-intensive method involves a high-temperature, high-pressure reaction between hydrogen and nitrogen. The nitrogen is readily available in the atmosphere; in modern ammonia synthesis, the hydrogen is usually supplied by natural gas. The Haber-Bosch process dramatically increased the availability and effectiveness of inorganic fertilizer and played a key role in facilitating rapid growth in crop yields and total food production during the Green Revolution of the 20th century.

Although the widespread use of inorganic fertilizers has led to dramatic improvements in global food security, these substances have also caused extensive environmental damage in some areas. Farmers seeking higher yields often apply more fertilizer than the crop can actually use. Excess nutrients dissolve in water and travel to rivers, lakes, and oceans, where they fertilize fast-growing algal blooms that deplete the aquatic environment of oxygen. This process, known as eutrophication, has created oxygen-starved "dead zones" in many of the world's oceans—including a 7,000-square-mile dead zone in the Gulf of Mexico.

Responsible farm management can ameliorate many of the negative effects of inorganic fertilizer. Soil testing, for example, allows farmers to pinpoint the nutrient content of their soils so that they apply no more than the optimal quantity of fertilizer. Accurate and timely testing not only prevents environmental damage, but it also helps farmers save money that they might have spent on a fertilizer safety margin. Additionally, farmers can prevent nutrient runoff by planting or restoring buffer strips of wetland and other natural vegetation around farms.

Fertilizer is a powerful tool for restoring soil nutrients and increasing agricultural output. Inorganic fertilizers will almost certainly be critical to improving food security and farm productivity in rural sub-Saharan Africa and other regions that continue to struggle with low crop yields. As farmers in these regions begin to increase their inorganic fertilizer use, it will also be important to ensure that they have access to the information and tools that they need to use avoid damaging agricultural land and other valuable natural resources.

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Reading Guide: Soil Nutrients and Fertilizer

1. List the mineral nutrients that are most important for plant growth.

2. What is the simplest way to restore soil nutrients? Why is this method not viable for many small farmers?

3. What crops can help restore soil nitrogen and why?

4. What are the key differences between natural (organic) and inorganic fertilizers?

5. What compound is the basis for most inorganic fertilizers, and how is it manufactured?

6. Describe the pros and cons of widespread inorganic fertilizer use.

7. What steps can farmers take to reduce the negative effects of inorganic fertilizer?

Crop Breeding and the Green Revolution

Information in this handout is adapted from "Crop breeding: The Green Revolution and the preceding millennia." UN Food and Agriculture Organization, March 2003. Complete text available online at: http://www.fao.org/english/newsroom/focus/2003/gmo2.htm. Other sources: Pingali, Prabhu, "The Green Revolution Forty Years Later," lecture given at Stanford University, October 6, 2011.

Ever since human beings began to practice settled agriculture more than 8,000 years ago, they have selected which plants to grow in cultivated fields. Early farmers chose plants that not only grew well, but that also seemed to have the best resistance to changing weather conditions, pests, and diseases. The plant populations selected by these farmers are the basis of today's crops that feed the world.

landrace—a wild plant that has adapted to specific local conditions through natural processes

In addition to wild plants and landraces (wild varieties that have adapted to specific local conditions through natural processes), there is a third type of agricultural plant: a plant bred on a research farm. Plant breeders aim, through crossing and selection of wild plants and specific landraces, to produce varieties that have desirable characteristics such as higher yields, resistance to pests and diseases, or better adaptation to their environment. The seed and planting material of these varieties are then supplied to farmers.

The potential of scientific crop breeding became more evident after the 1960s. Around that time, Dr. Norman Borlaug, a U.S. scientist working in Mexico, used it to breed new wheat varieties that had higher yields and were more responsive to inputs such as fertilizer and irrigation water. Until then, attempts to increase productivity of existing local varieties had been only partially successful. Local varieties responded to modern fertilizers, but rapid fertilizer-induced growth caused them to outgrow the strength of their stalks so that they toppled over.

After years of painstaking work, Professor Borlaug crossed local wheat with Japanese dwarf varieties to produce shorter, sturdier plants that could productively utilize greater amounts of fertilizer. The resulting wheat varieties were credited with averting the mass starvation that faced the developing world in the 1960s. Those wheat varieties have been adopted and grown widely, particularly in India, Mexico, and Pakistan. Professor Borlaug won the Nobel Peace Prize in 1970. Meanwhile, scientists extended the principles of modern crop breeding to other staple crops. The Green Revolution had begun.

The Green Revolution—a series of breakthroughs in crop breeding and agricultural technology that occurred during the 1960s and 1970s. The Green Revolution led to dramatic increases in staple crop yields, particularly in Asia and Latin America.

Crop breeding during the Green Revolution focused on three major grain crops: wheat, maize, and rice. Improvements in the yields of these crops lifted millions of people out of poverty during the latter half of the 20th century. However, early efforts overlooked several lesser-known crops—including sorghum, millet, and cassava—that are widely produced and consumed in Africa's poorest developing regions. Crop scientists have now begun to turn their attention to those crops; their results could dramatically improve yields and food security in developing African countries.

However, the 1990s and 2000s have also seen an increase in crop breeding efforts from the private sector and a decrease in government funding for scientific crop research. Private companies have helped drive improvements in agricultural science, but these companies have also obtained strict patents that can make it difficult for farmers in developing countries to access and afford improved varieties. An effort that balances public and private investment, and that keeps the needs of poor small farmers at the forefront, will be necessary if crop breeding is to continue to reduce poverty and hunger in the 21st century.

Reading Guide: Crop Breeding and the Green Revolution

1. How do plant breeders develop new crop varieties?

2. What desirable crop characteristics do crop breeders try to select for?

3. Describe Dr. Norman Borlaug's contributions to crop breeding and food security.

4. What crops did Green Revolution breeders focus on? What important crops did they overlook?

5. Describe two ways that the focus of crop breeding efforts has shifted in the post–Green Revolution period. What are the (positive and negative) effects of these changes?

Quiz

1. A farmer harvests 30 metric tons of wheat from 10 hectares of land. What is his yield?

2. Rank the following crops in order from lowest to highest average yield: soybeans, maize, cassava, millet.

3. Between 1980 and 2010, which global region experienced the:
   a. fastest increase in crop productivity?

   b. slowest increase in crop productivity?

4. List three crops that received dedicated attention from Green Revolution crop breeders, and then list three crops that were largely overlooked.

5. Describe Dr. Norman Borlaug's contributions to global food security.

6. Describe Fritz Haber and Karl Bosch's contributions to global food security.

7. List at least two shortcomings of the Green Revolution.

Viewing Guide: Prabhu Pingali Video Clip

In this lesson, you learned about the Green Revolution and its effect on poverty and hunger in the developing world. You will now watch a brief video clip featuring a prominent individual who experienced the Green Revolution's effects firsthand. Prabhu Pingali, Deputy Director of Agricultural Development for the Bill and Melinda Gates Foundation, was a child in India when high-yielding rice varieties first entered the country in the 1960s. Here, Pingali describes the changes that the Green Revolution brought to his small village, and he comments in general on the revolution's far-reaching benefits and inescapable shortcomings.

Read through the following questions before watching the video clip. Try to record the answers to these questions as you watch. Note unfamiliar terms and any other questions in the spaces provided at the end of the guide. Your teacher will collect your notes at the end of the lesson.

1. What crop do farmers in Prabhu Pingali's village grow?

2. In what year did the Green Revolution come to Pingali's village?

3. How did the Green Revolution affect Pingali's life?

4. During the 1950s and 1960s, the global community was concerned about Asia's high ________________ and low _________________.

5. Since the 1960s, global ___________________ has grown faster than global _______________.

6. Since the 1960s, global food prices have _____________.

7. List two reasons that this trend in prices has benefitted small farmers:

a. Small farmers tend to be net ______________ of food.
Restate (a) in your own words:

b. During the Green Revolution, ________________________________ declined faster than _________________.
Restate (b) in your own words:

8. If the Green Revolution had not occurred, child malnutrition in the year 2000 would have been ___________ percent higher.

9. Between 1965 and 1985, rural poverty in India fell from ______ percent to ______ percent.

10. Pingali believes that the success of the Green Revolution created a sense of _______________, which led to declining investments in __________________________.

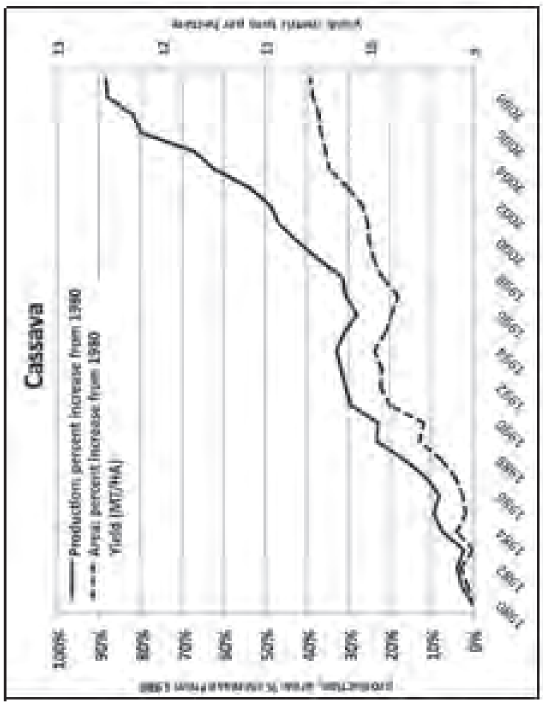
Unfamiliar terms:

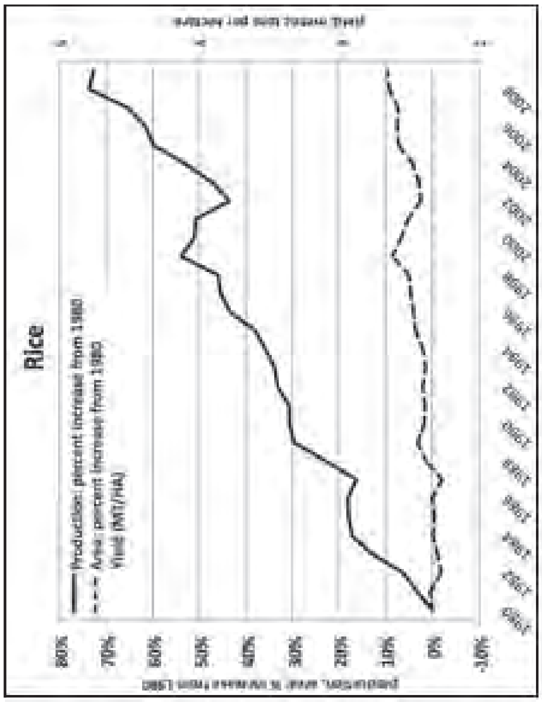
Questions about the lecture/for the speaker:

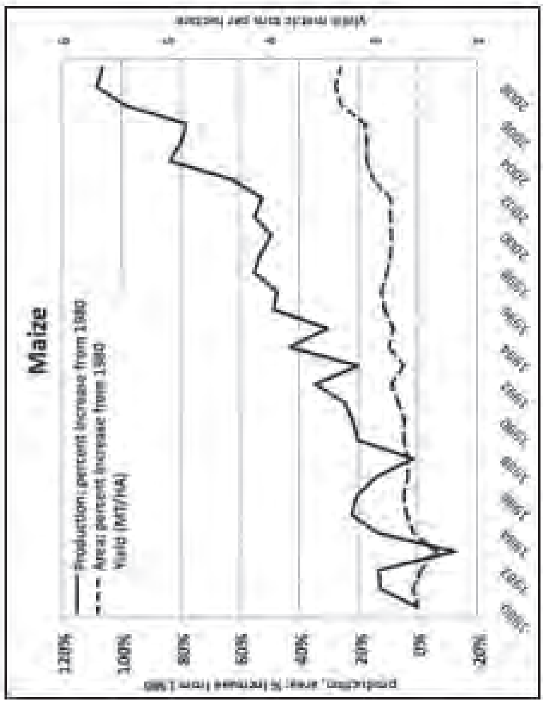
Crop Productivity Solution

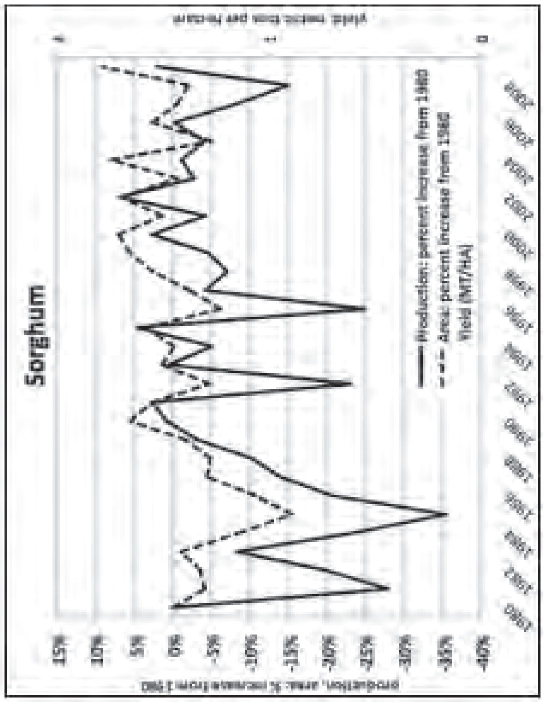
Production	Area Harvested	Yield
The total quantity of the crop harvested in a given year, usually measured in kilograms or metric tons (one metric ton = 1,000 kg)	The total land area used to produce the crop, usually measured in acres or hectares (one hectare = 2.47 acres)	The land area required to produce a fixed quantity of the crop, usually measured in metric tons per hectare. Yield may also refer to inputs other than land, such as water and fertilizer.
Million metric tons, 2009–2010:	Million hectares, 2009–2010:	Metric tons per hectare, 2009–2010:
829: Maize	223: Wheat	12.4: Cassava
649: Wheat	163: Corn	5.08: Maize
451: Rice	157: Rice	4.30: Rice
264: Soybeans	103: Soybeans	2.91: Wheat
234: Cassava	51: Barley	2.57: Soybean
124: Barley	41: Sorghum	2.44: Barley
66: Sorghum	34: Millet	1.60: Sorghum
34: Millet	19: Cassava	1.00: Millet

Yield Trend Solution





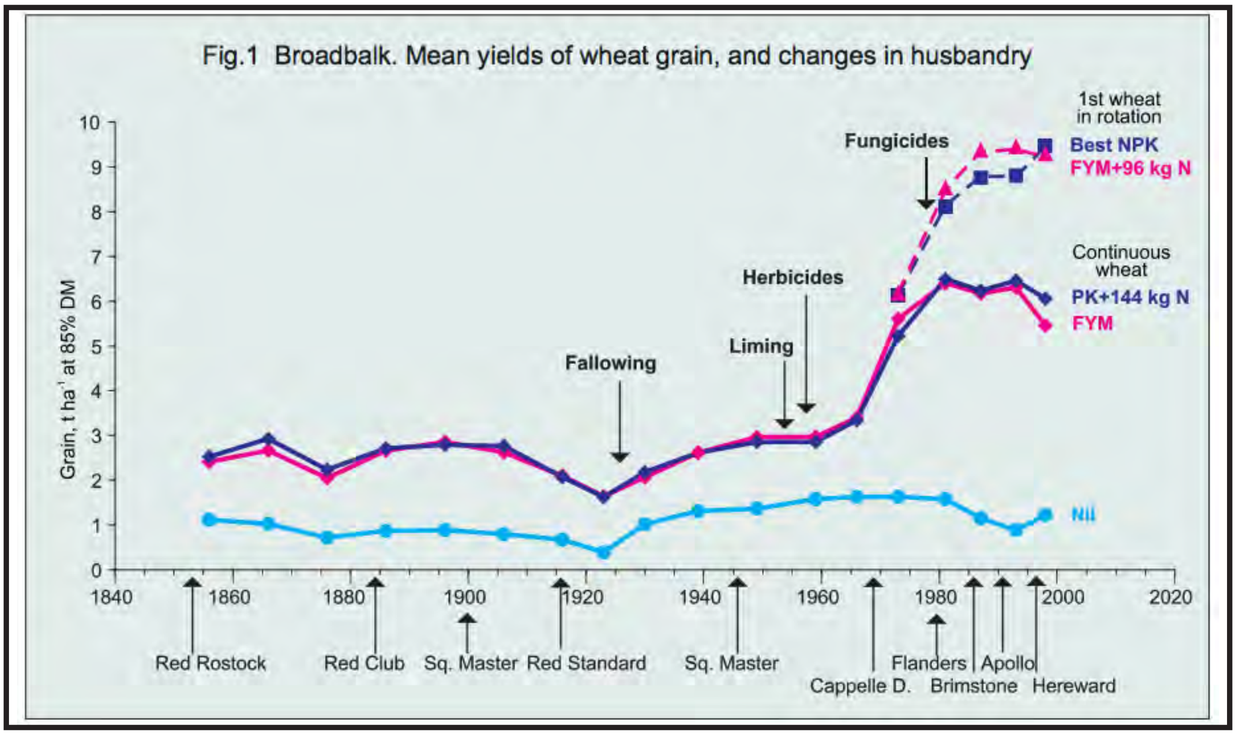




Long-Run Yield Trend

Rothamsted Research Farm, located just outside London, England, is the world's longest-running agricultural research center. Observations on some of the farm's research plots have been ongoing since the mid-1800s.

The chart below shows the long-term trend in wheat yields on one such plot, the Broadbalk Field. The different lines on the chart represent different varieties of wheat. Focus on the (dashed) pink and dark blue lines, which represent the most productive varieties.



Source: Rothamsted Research Farm, "Guide to the Classical and other Long-term Experiments, Datasets and Sample Archive," available from http://www.rothamsted.ac.uk. Accessed 17 Nov 2011.

Answer the following questions:

- Describe the trend in yields from 1860 to 1960.
- Describe the trend in yields from 1960 to 2000.
- What accounts for the change in 1960? The chart provides some clues, but feel free to add your own ideas.

Answer Key to Handout 2 (Mapping Crop Productivity)

1. Complete the table with the highest and lowest yields (among the top ten producing countries) for each crop:

	Lowest top 10 yield	Top 10 country with lowest yield	Highest top 10 yield	Top 10 country with highest yield	Lowest yield is ___% of highest yield
Cassava	8.11	Dem. Rep. of the Congo	34.37	India	24%
Maize	2.00	India	10.34	USA	19%
Rice	2.87	Thailand	6.58	China	44%
Sorghum	0.63	Sudan	4.53	USA	14%

2. What factors might account for the differences in yields between crops?
Answers will vary—award points for logical, creative answers that reflect knowledge of the basic crop characteristics covered on Handout 1, Crop Productivity. *Students should also demonstrate understanding of the crop productivity measures, e.g., that yield is measured in metric tons per hectare. Possible factors include:*
   - *Some crops—particularly tubers, such as cassava—are naturally denser by weight.*
   - *Crops that have tall stalks or have edible roots can grow above or below ground, facilitating higher production on less land.*
   - *Some crops are more tolerant of environmental stresses and can grow densely packed even in poor, dry soils.*
   - *Certain crops are more prevalent in developed countries where productivity-enhancing technologies are more widespread and social, political, and economic conditions facilitate best practices (covered in greater detail in question 5).*

3. Do the countries and regions with the highest yields also tend to plant more area and harvest greater quantities? Why do you think this is or is not the case?
Answers will vary slightly, but students should mention the following key points:
   - *Countries with high yields do tend to have higher overall production.*
   - *Countries with high yields and production do not necessarily plant more area. In some cases, the lowest yields correlate with the largest planted area.*
   - *High yields are a result of high production on minimal area, so it makes sense that high yields would correlate with high production but not necessarily with high area.*
   - *Countries that have high production, yield, AND area are most likely planting more area because yields are high—it is most profitable for farmers to plant the crop with the highest yield.*

4. Do any countries or regions have unusually high yields across all four crops? Do any countries or regions have unusually low yields? Describe any trends you see:
Answers will vary somewhat—award points for insightful answers that reflect the data given. Key points include:
   - *The United States has the highest yield of two crops: maize and sorghum.*
   - *Maize and sorghum yields are also high in Argentina.*

- *Rice and cassava yields are highest in Asian countries.*
- *Where represented, African countries tend to have the lowest yields—the exception is South Africa's maize yield, which is about average among the top 10 producers.*

5. Brainstorm a list of factors that might account for the differences in yields between countries and regions. Consider economic, political, and social factors in addition to environmental constraints; try to think of at least 10 factors.
   Answers will vary—award points for logical, creative answers that draw on the information presented in Lesson One. Possible factors include:
   - *Fiscal resources available for agricultural research and development (poorer countries will have fewer resources).*
   - *Availability of basic education and training in best farming practices.*
   - *Availability of productivity-enhancing resources (irrigation, fertilizer, etc).*
   - *Market incentives for food production (in poorer countries, the local population cannot pay farmers good prices for their crops).*
   - *Stability of farmers' rights to their land (farmers without secure land ownership have less incentive to care for the land, resulting in long-term yield declines).*
   - *Political unrest or violent conflict that disrupts food production.*
   - *Health problems that detract from farmers' productivity.*
   - *Natural disasters or climate variability.*
   - *Differences in soil suitability for agriculture.*

6. How do national and regional differences in crop yields compare with national and regional differences in poverty and hunger rates?
   Answers will vary slightly, but all students should recognize that regions in which poverty and hunger rates are relatively low or declining rapidly (e.g., Asia and the Americas) have the highest crop yields, while areas that struggle with the high and persistent poverty and hunger rates (sub-Saharan Africa) have low crop yields.


Japan {4.41}
Burma {4.09}
Vietnam (16.82) {5.23}
Philippines {3.59}
Australia /3.57/
China [5.26] {6.58} /3.00/
Indonesia (18.75) [4.24] {5.00}
India (34.37) [2.00] {3.19} /.96/
Thailand (22.68) {2.87}
Bangladesh {4.20}
Ethiopia /1.84/
Tanzania [5.47]
Ukraine [5.02]
Sudan /.63/
DRC (8.11)
South Africa [4.96]
France [9.10]
Nigeria (11.77) /1.11/
Angola (12.90)
Ghana (13.81)
Brazil (13.86) [3.71] {4.41} /2.34/
Argentina [5.61] /3.95/
United States [10.34] /4.35/
Mexico [3.24] /3.61/
Legend: - (Cassava) - [Maize] - {Rice} - /Sorghum/

Answer Key to Handout 3 (Time Trends in Crop Productivity)

1. Which crop experienced the greatest percentage increase in production between 1980 and 2009?
   Maize; production more than doubled.

2. Which crop experienced the least increase in production?
   Sorghum; production declined over many years and experienced no net increase.

3. Which crop experienced the greatest increase in yield?
   Because students do not have enough information to calculate yield increases precisely, any answer but "sorghum" would be acceptable here. The correct answer in absolute terms is cassava—cassava yields increased by about 3.25 metric tons per hectare—but both maize and rice experienced much larger percentage increases, about 65 percent and 55 percent, respectively; cassava yields increased only about 35 percent.

4. Which crop experienced the least increase in yield?
   Sorghum; the minimal increase in sorghum production translates to a similarly minimal yield increase (less than 10 percent, or about 0.1 metric ton per hectare).

5. In general (across all four crops), how much did the area harvested change between 1980 and 2009? Compare and contrast the change in area with the changes in production and yield, and offer an explanation for the differences.
   Students should recognize that production and yields increased overall much more than area harvested; area harvested did not increase by more than 40 percent for any of the four crops. Explanations will vary—award points for the simple and correct observation that if yield increased, production must have increased more than area. Exceptional answers will also mention potential factors in the yield increase, such as improvements in technology (irrigation, fertilizer, crop breeding, mechanization, etc.), shifts in weather and climate, political and social stabilization, etc.

6. Why do you think that production and yields increased more for some crops than for others?
   Answers will vary—award points for logical, creative answers that reflect knowledge of the characteristics of each crop (refer to Handout 1: Crop Productivity*). For example, students might comment on the fact that these crops are grown in different regions; poorer regions, such as Asia and sub-Saharan Africa, will not have as many resources to devote to agricultural research and development. Other good responses might mention that yields of hardier crops, such as sorghum and cassava, might not have much "room" to increase (i.e., yields of these crops might be near the yield ceiling) even in response to irrigation and fertilization (this is not necessarily true, but it is a logical conclusion from the available information).*

Finally, examine the last chart in the handout, which shows changes in regional maize yields between 1980 and 2005. Note that the yield in each year is expressed in the same way that production and area were in the previous four charts, i.e., as a percentage change from the 1980 yield. Answer the following questions based on the maize yields chart:

7. In which region did maize yields increase the most between 1980 and 2009?
   South America; yields more than doubled.

8. In which region did maize yields increase the least?
   Africa; yields increased just over 20%.

9. How do these regional time trends in maize yields compare with regional time trends in hunger and poverty?
   Answers may vary somewhat, but all students should recognize that regions that experienced significant declines in poverty and hunger between 1980 and 2009 (e.g., Asia) also experienced significant increases in maize yields, while regions that experienced increases in poverty and hunger (e.g., Africa) experienced minimal increases in yields.

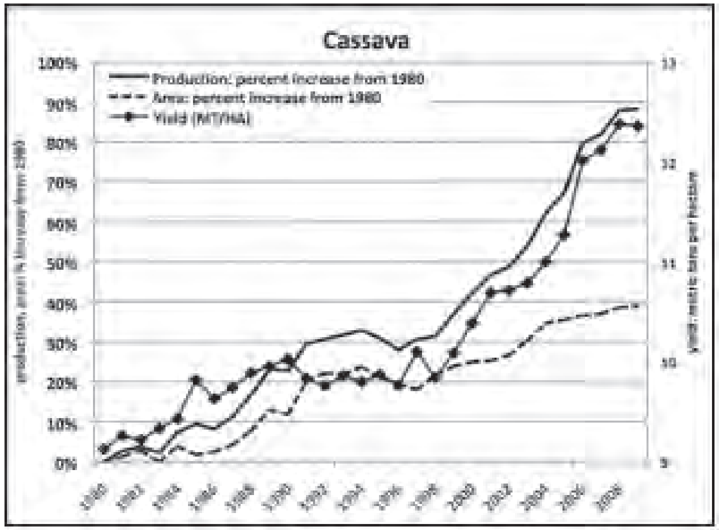
10. Suggest several reasons that a country or region might experience lower-than-average yield increases.

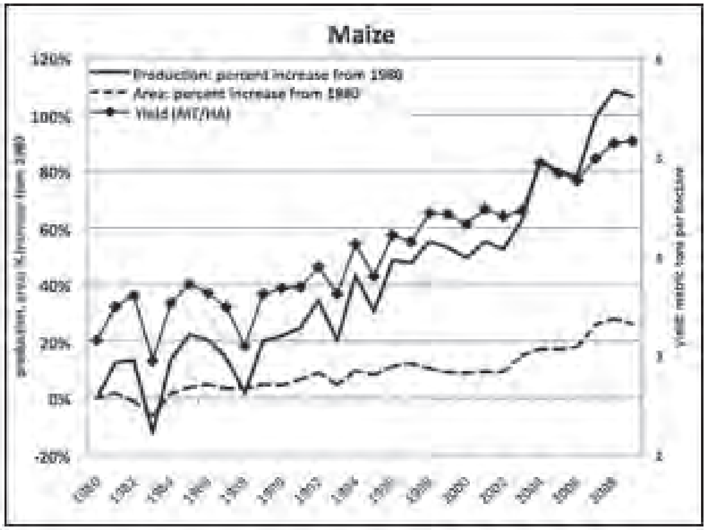
Answers will vary—award points for logical, creative answers that reflect an appreciation of the differences in conditions between regions. Possible reasons include:

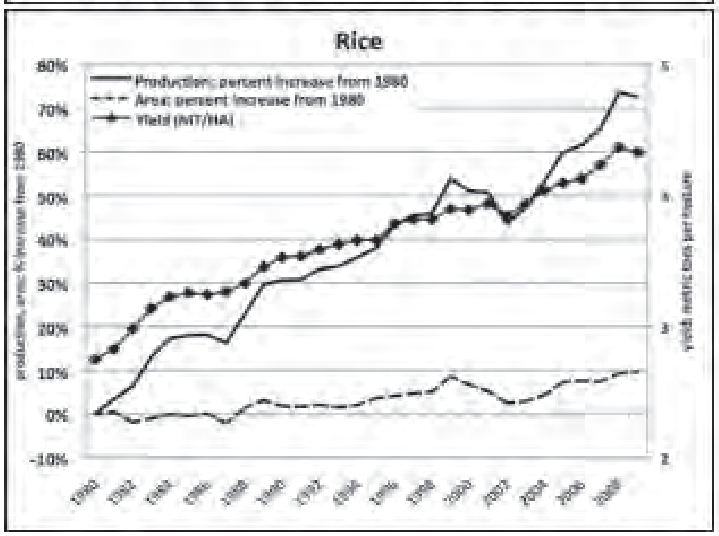
- *A country lacks resources (technology, financing, organization) to provide farmers with modern productivity-enhancing inputs.*
- *A country lacks resources to pursue productivity-enhancing agricultural research.*
- *A country's climate or soils preclude attainment of high yields.*
- *Health problems, lack of education, or civil/political disruptions prevent farmers from maintaining efficient farming practices.*
- *The country's economy and markets do not provide the incentive to improve yields (e.g., farmers do not have a reliable market in which to sell surplus production).*
- *The country had high yields to start with, leaving less room for improvement (this was the case in North America and Europe compared with Asia and South America between 1980 and 2009).*

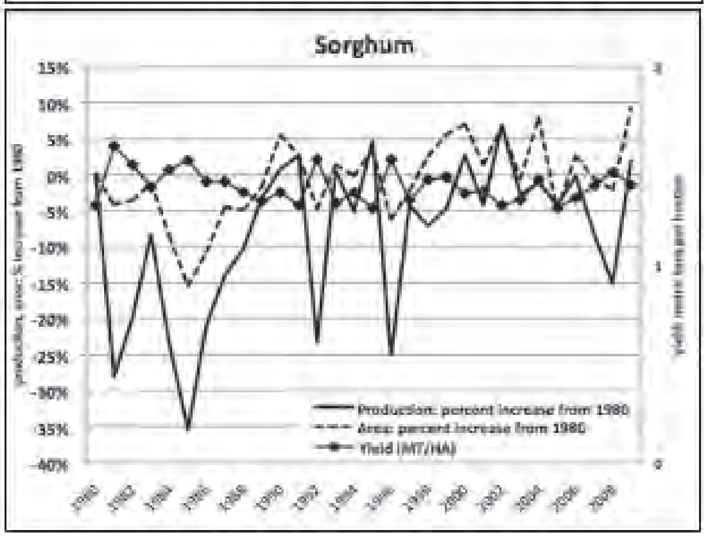
11. Maize is a good crop to use as a reference when making general comparisons of agricultural productivity between regions. Why is this the case?
   As mentioned in Handout 1, Crop Productivity*, maize is cultivated in nearly every region of the world, facilitating consistent comparisons of yields and production between countries. Also note (referring to Handout 2,* Mapping Crop Productivity*) that the every region shown on the maize yields chart is represented among the world's top 10 maize producers.*

Based on the trends in global production and area harvested for each crop, sketch the correct trend in the crop yield. An accurate range in yield values is given on the right-hand axis; you may find it helpful to refer to the Crop Productivity exercise for the exact 2009 yield value, which gives the height of the yield line at its rightmost end. Note that while production and area are expressed in percent increase from 1980, yield is expressed (as usual) in metric tons per hectare.









Answer Key to Handout 5
(Reading Guide: "Green Revolution: Curse or Blessing?")

1. How did farmers generally achieve crop production increases in the 19th century, and how did their methods change at the beginning of the 20th century?
   Prior to the 20th century, farmers achieved most yield increases through increases in the amount of land area cultivated. During the 20th century, advances in crop breeding and fertilizer and pesticide manufacturing helped farmers dramatically improve crop yields, allowing them to grow more food without bringing more land into cultivation.

2. What crops and regions were the first to benefit from the Green Revolution?
   Asia and Latin America benefitted most from improvements in rice and wheat breeding and cultivation during the early stages of the Green Revolution.

3. What traits did crop breeders look for to create new high-yielding varieties?
   Responsive to nutrients; short, stiff straw; mature quickly; grow at any time of year; resistance to pests and disease; desirable cooking and consumption traits.

4. How did farmers change their practices as they adopted high-yielding varieties?
   Farmers replaced other crops with new varieties of wheat and rice, significantly increasing the amount of land area devoted to growth of the two staple grains. The new fast-growing varieties also allowed farmers to grow multiple cycles of a crop during the year. These changes helped to more than double cereal production in Asia between 1970 and 1995.

5. What region was left out of the Green Revolution, and why?
   The Green Revolution largely bypassed Africa, particularly sub-Saharan Africa, for many reasons, including poor infrastructure, high transport costs, limited investment in irrigation, and pricing and marketing policies that penalized farmers.

6. Describe how the Green Revolution affected income, poverty, and nutrition in Asia.
   Increases in agricultural productivity increased farmers' incomes, allowing them to make investments in inputs and services that in turn fueled the growth of Asian rural economies more generally. Per capita incomes almost doubled, and poverty rates dropped nearly 50 percent. With more food widely available at lower prices, calorie consumption increased, and Asians were able to diversify their diets to include more fruits, vegetables, oils, and livestock products.

7. What consequences did the Green Revolution have for small farmers and the rural poor?
   The Green Revolution had some negative consequences for small famers and the rural poor. Critics have argued that lack of credit and basic resources such as irrigation water made poor, small farmers less able than large farmers to take advantages of advances in crop breeding and fertilizer. Rapid increases in food production lowered the prices received by farmers of all sizes for their crops, a change that hit small farmers hard. Increased mechanization also left some rural wage laborers without employment. However, those small farmers that did adopt new technologies—and many were eventually able to do so, although they lagged somewhat behind large farmers—realized proportionally higher yield and production increases, resulting in substantial income gains.

8. How can governments and aid organizations ensure that agricultural development helps small farmers? Summarize the brief's suggestions in your own words.
   Governments and aid organizations need to make sure that new technologies are easy for small farmers to adopt. This means promoting technologies suitable for small as well as large farms, and teaching small farmers to use them properly; giving small farmers access to loans to purchase seeds, fertilizer, etc; conducting productivity-enhancing research on the crops grown by small farmers; and defending small farmers' property rights.

9. What natural resource did farmers need in order to fully capitalize on the technological development of the Green Revolution?
   Water; in areas where natural water or irrigation systems did not exist, the Green Revolution had less of an impact, leading to regional inequality even within countries that benefitted at a large scale.

10. List several ways in which the Green Revolution affected the natural environment.
    Fertilizer and pesticides have poisoned people and animals; irrigation pumping has depleted groundwater levels; heavy dependence on cereals has led to loss of biodiversity; higher yields have prevented the clearing of forests and other natural landscapes for agriculture.

11. What steps can help reduce the negative environmental effects of Green Revolution technologies?
    Provide training for farmers in appropriate use of pesticides and fertilizers; avoid subsidies that dramatically lower the prices of environmentally harmful inputs; encourage biological pest control, precision farming, and crop diversification; monitor and regulate water quality.

12. How did the Green Revolution indirectly affect the world's poor, and why are indirect impacts likely to be weaker in the future?
    Poor populations benefitted largely through reduced food prices and increased migration and employment opportunities. These benefits are likely to be reduced in the future due to globalization, because the tight integration of global markets and the ease with which food and other products are transported throughout the world have made food prices less responsive to increases and decreases in local production and have made agriculture less important in the lives of the rural poor.

Answer Key to Handout 7 (Reading Guide: Soil Nutrients and Fertilizer)

1. List the mineral nutrients that are most important for plant growth.
   Nitrogen, phosphorous, potassium, calcium, magnesium, and sulfur.

2. What is the simplest way to restore soil nutrients? Why is this method not viable for many small farmers?
   The simplest way to restore soil nutrients is by fallowing, or leaving land out of production for one or several crop seasons. Small farmers may rely on one small plot of land for all their food and/or income and cannot afford to leave that land fallow for even one season.

3. What crops can help restore soil nitrogen and why?
   Leguminous plants such as beans and peas take up nitrogen from the air and release it into the soil when they die. In contrast to most other crops, these plants add to rather than deplete the soil stock of nitrogen.

4. What are the key differences between natural (organic) and inorganic fertilizers?
   Answers should mention at least one of the following points; strong answers will mention both:
   - *Organic fertilizers are naturally occurring substances (animal manure, powdered rock, decomposed vegetable matter); inorganic fertilizers are chemically manufactured by humans.*
   - *Inorganic fertilizers tend to contain very high concentrations of a single nutrient; organic fertilizers tend to have a balanced, low-concentration nutrient profile.*

5. What compound is the basis for most inorganic fertilizers, and how is it manufactured?
   Ammonia is the basis for most inorganic fertilizers. Ammonia is manufactured through the Haber-Bosch process, a high-energy chemical reaction between nitrogen from the atmosphere and hydrogen from natural gas or petroleum.

6. Describe the pros and cons of widespread inorganic fertilizer use.
   - *Pros: dramatic increases in crop production and global food security.*
   - *Cons: environmental effects from fertilizer overapplication, most notably "dead zone" formation in aquatic ecosystems downstream from farms; buildup of excess nutrients in soil resulting in unfavorable chemical changes.*

7. What steps can farmers take to reduce the negative effects of inorganic fertilizer?
   Reduce fertilizer application (by pinpointing the efficient quantity through soil testing); restore wetlands and other natural vegetation buffers around farms.

Answer Key to Handout 9 (Reading Guide: Crop Breeding and the Green Revolution)

1. How do plant breeders develop new crop varieties?
   Crop breeders develop new varieties by selectively crossing wild varieties and landraces on research farms.

2. What desirable characteristics do crop breeders try to select for?
   Higher yields, resistance to pests and diseases, and better adaptability.

3. Describe Dr. Norman Borlaug's contributions to crop breeding and food security.
   Dr. Borlaug developed new wheat varieties that could effectively utilize modern fertilizers. Natural varieties collapsed under their own weight when fertilized; Borlaug's varieties had shorter, stiffer stalks that could hold the weight of the rapidly growing plant. The new wheat varieties helped to avert starvation in many countries of the developing world, including India, Mexico, and Pakistan, and scientists were able to extend Borlaug's principles to achieve similar yield gains for rice and maize.

4. What crops did Green Revolution breeders focus on? What important crops did they overlook?
   Green Revolution breeders focused on major staple grains: wheat, rice, and maize. They overlooked many lesser-known food staples that are commonly grown in developing African countries, such as sorghum, millet, and cassava.

5. Describe two ways that the focus of crop breeding efforts has shifted in the post–Green Revolution period. What are the (positive and negative) effects of these changes?
   Modern breeders have begun to focus on the crops that Green Revolution scientists overlooked—their work could dramatically improve food security in developing Africa. However, a larger share of crop breeding projects are now undertaken by private firms, whose strict patents may prevent dissemination of improved varieties to small farmers.

Answer Key to Handout 10 (Quiz)

1. A farmer harvests 30 metric tons of wheat from 10 hectares of land. What is his yield?
   3 metric tons per hectare.

2. Rank the following crops in order from lowest to highest average yield: soybeans, maize, cassava, millet.
   Millet, soybeans, maize, and cassava.

3. Between 1980 and 2010, which global region experienced the:
   a. fastest increase in crop productivity?
      South America (students who answer Asia or East Asia should receive partial credit).
   b. slowest increase in crop productivity?
      Africa (specifically sub-Saharan Africa).

4. List three crops that received dedicated attention from Green Revolution crop breeders, and then list three crops that were largely overlooked.
   Received attention: maize, rice, and wheat.
   Overlooked: cassava, millet, and sorghum.

5. Describe Dr. Norman Borlaug's contributions to global food security.
   Developed new shorter, stronger wheat varieties that could effectively utilize modern fertilizer.

6. Describe Fritz Haber and Karl Bosch's contributions to global food security.
   Developed a process for synthesizing ammonia, which dramatically increased the availability of inorganic fertilizer.

7. List at least two shortcomings of the Green Revolution.
   Possible answers: negative environmental effects of increased fertilizer use; benefits didn't spread to low-rainfall areas or regions not suited for staple grain cultivation (especially sub-Saharan Africa); small farmers didn't have access to new technologies.

ANSWER KEY TO HANDOUT 11 (VIEWING GUIDE: PRABHU PINGALI VIDEO CLIP)

1. What crop do farmers in Prabhu Pingali's village grow?
Farmers in Pingali's village continue to grow rice, more than four decades after Pingali's story took place. Remind students of the following facts about rice from Handout 1, Crop Productivity*:*
   - *Rice is grown in over 100 countries worldwide—primarily in Asia.*
   - *Rice may account for up to 80% of the calories in a poor Asian family's diet.*
   - *Rice plants are generally grown in lowland areas, such as river valleys and coastal deltas, that are prone to sudden flooding.*

2. In what year did the Green Revolution come to Pingali's village?
1967. The revolution began with a single small test plot of IR8, a high-yielding rice variety; within a year, all the farmers in the village were planting the new variety. For discussion: What characteristics might crop breeders have selected for in developing IR8? (Good answers include: short, stiff straw that could stand up under a heavy head of grain; resistance to pests and diseases; resistance to flooding; quick growth under a variety of conditions).

3. How did the Green Revolution affect Pingali's life?
Because the higher yields possible with IR8 dramatically increased his family's income, Pingali was able to attend school and go on to a career in agricultural development. For discussion: Many Green Revolution families like Pingali's used surplus income to send children to school. What other short and long-term investments do you think families might have made? (Good answers include: paying for emergency food, maintenance, or medical care; purchasing equipment or upgrading infrastructure such as irrigation systems; purchasing more land or hiring farm help; buying additional seed for the next growing season).

4. During the 1950s and 1960s, the global community was concerned about Asia's high ________________ and low _________________.
High population and low food supply—resulting in low food availability per capita. For discussion: Pingali comments that the global community debated the need for triage in the face of this problem—what does he mean by triage*? (Good answer: Allowing some segments of this population to die from famine, thus freeing resources to help other segments.) Do you think that this approach to the problem would have been effective? Why or why not?*

5. Since the 1960s, global ___________________ has grown faster than global _______________.
Food production has grown faster than population, resulting in greater food availability per capita. Note that increases in crop production since the 1960s have been achieved primarily through increases in crop yields, with the total land area under cultivation remaining roughly constant.

6. Since the 1960s, global food prices have _____________.
Fallen. For discussion: Why did prices fall? (Good answer: because supply increased; commodities that are in ready supply tend to command a lower price. Have students think of some examples/contrasts, e.g., gravel is much cheaper than diamonds.)

7. List two reasons that this trend in prices has benefitted small farmers:

a. Small farmers tend to be net ______________ of food.

Consumers. Restated: Most small farmers buy more food than they sell.

b. During the Green Revolution, ________________________________ declined faster than _________________.

Food production costs declined faster than food prices. Restated: Small farmers saved more in producing food at a lower cost than they lost in selling food at a lower price.

8. If the Green Revolution had not occurred, child malnutrition in the year 2000 would have been ___________ percent higher.
Six to eight percent higher; note that this figure is an estimated global average, and that child malnutrition might have been much higher in areas of the developing world (e.g., South Asia) where the Green Revolution had the greatest impact.

9. Between 1965 and 1985, rural poverty in India fell from ______ percent to ______ percent.
Sixty percent to 40 percent; poverty declined an additional 10 percent between 1985 and 2000.

10. Pingali believes that the success of the Green Revolution created a sense of _______________, which led to declining investments in __________________________.
Complacency, which led to declining investments in agricultural development. For discussion: What might be some other reasons for declining investment and/or for a slowdown in poverty reduction and crop yield improvements? (Good answers include other events/funding priorities, such as natural disasters or global health crises—consider the AIDS crisis of the 1980s. Continued rapid population growth might also have limited progress in poverty reduction; improvements in crop yields may have slowed once the "low-hanging fruit" of the science had been captured—in other words, once breeders had tried the most obvious ideas!)

Lecture Summary: "African Agricultural R&D and Productivity Growth in a Global Setting"

The following summary appeared on the Stanford Center for Food Security and the Environment Web site on October 18, 2011. Review this summary before showing the lecture clip in class; instructors may also wish to make the summary available to interested students for supplementary reading.

18 October 2011

Shades of green—food security experts review mixed outcomes of the Green Revolution

Productivity gains of the mid-20th century had far-reaching impacts, say Prabhu Pingali and Philip Pardey, but didn't fix all the problems of that era—or this one

Four decades ago, farmers in Prabhu Pingali's small eastern-Indian village began planting a new rice variety known as IR8. The high-yielding strain dramatically increased the productivity of rice cultivation in the region. Record harvests and profits allowed Pingali's family to send their son to school and then to college, launching him on a path that led to his current position as Deputy Director of Agricultural Development at the Bill and Melinda Gates Foundation.

Pingali's story, and many others like it, came about as a result of the rapid advances in agricultural technology that characterized the "Green Revolution" of the 1960s and 1970s. Agricultural scientists of the period worked aggressively to bring modern farming techniques, including high-yielding crop varieties, to the developing world. Their efforts sparked a surge in agricultural productivity that lifted millions of small farmers out of poverty and dispelled widespread fears of famine in Asia's developing countries.

But even direct beneficiaries, including Pingali, acknowledge the Green Revolution's unintended consequences. Speaking on the Stanford campus this October, Pingali reflected on the revolution's failures as well as its successes, highlighting problems that the advances of the 20th century left unsolved.

"I think of myself as being here today because of what the Green Revolution did," Pingali said. But, he added, "As an Indian, I feel we could have done a lot better."

The two-hour symposium was the fifth event in a series focused on global food security and food policy, sponsored by Stanford's Center on Food Security and the Environment and funded by the Gates Foundation.

Pingali began his talk by celebrating the Green Revolution's triumphs, including its far-reaching impact on food security. Developing-country farmers who adopted high-yielding crop varieties, he said, significantly increased their output and incomes; production surpluses also exerted downward pressure on global food prices, increasing the purchasing power of poor food buyers in both urban and rural areas. Pingali cited a 2003 study that found that today's global per capita calorie consumption would be nearly 15 percent lower, and child malnutrition 6–8 percent higher, had the Green Revolution not occurred.

Speaking after Pingali, University of Minnesota Professor Philip Pardey reiterated the Green Revolution's welfare-enhancing consequences. Pardey provided a more rigorous quantitative analysis, presenting data that showed that yields of major cereal crops more than doubled, and real food prices fell by over 50 percent, between 1960 and 2005.

However, Pardey expressed concern about an apparent slowdown in progress since the end of the 20th century. He cited declining yield growth rates, and the food price spikes of 2008–2010, to emphasize the need for a renewed commitment to agricultural science and food security policy.

Both Pingali and Pardey also drew their audience’s attention to the unevenness of the Green Revolution’s benefits. The yield gains of the 1960s and 1970s, Pardey said, were accompanied by increasing spatial concentration of food production, as some regions and countries benefited disproportionately from emerging agricultural research.

Pingali noted that the Green Revolution largely bypassed sub-Saharan Africa, home to some of the world’s most food-insecure populations. Unlike the developing nations of Eastern Asia, he said, most African countries still lack the market infrastructure to support rapid expansion of the agricultural sector. Low population densities, resulting in weak local food demand, and insufficient government support for agricultural development, have further inhibited productivity gains in these countries.

Additionally, many African farmers rely primarily on minor “orphan” crops, such as cassava, rather than on the global staple grains—rice, wheat, and maize—that received most attention from Green Revolution scientists. Although modern crop breeders have begun to develop high-yielding orphan crop varieties, research in this area remains sparse. Major breakthroughs and significant yield gains may not occur for decades.

Even if scientists do develop improved crop varieties for Africa, Pingali said, increasingly stringent intellectual property laws could inhibit their distribution to poor rural farmers. Meanwhile, looming challenges such as population growth and global climate change will further complicate the future path of agricultural development.

Like Pardey, Pingali warned against complacency. Though the advances of the 1960s and 1970s were impressive, he concluded, researchers will need to “reach beyond the low-hanging fruit” to continue to increase productivity—intensifying the study of orphan crops, for example, and developing new crop strains that will grow well under extreme climate conditions.

According to Pingali, the first Green Revolution proved that “innovation, technological change, and just plain old human ingenuity” can overcome seemingly insurmountable obstacles to global food security. Four decades later, agricultural development faces a new round of challenges, but Pingali believes that innovation and ingenuity will produce new solutions. “We’ve done it before,” he declared, “and I’m sure we can do it again.”

Lesson Three

Agriculture and Health

Organizing Questions

- How does human health affect agricultural productivity, and how do agricultural productivity and production systems affect human health?
- Why might an individual who consumes sufficient calories daily still be considered nutritionally deficient or food insecure?
- What are the most important micronutrients that humans must consume daily for good health, what foods contain these nutrients, and why is it difficult for many poor consumers to meet daily micronutrient requirements?

Introduction

In this lesson, students learn about several connections between agriculture and human health. The lesson begins with a summary of major issues such as quantity and quality of food consumption, environmental health, and worker safety. Students complete an in-class study of micronutrients—their importance for human health, and their connections to agriculture through the production of animal products and produce crops—and an independent case study focused on the manifestations of agriculture-health links in a particular developing country. The lesson includes a card game that illustrates the challenges of meeting calorie and micronutrient needs on a limited food budget.

Objectives

In this lesson, students will

- learn how agriculture and human health are linked through effects on productivity, nutritional status, environmental quality, and worker safety;
- explore agriculture-health links in different global regions, and think creatively about how these links might appear in a particular household or community;
- learn about the importance of dietary diversity and the health consequences of various micronutrient deficiencies;
- study the nutrient profiles of common staple and luxury foods; and
- appreciate the challenges of meeting daily calorie and nutrient requirements on a limited food budget.

Materials

- Handout 1, *Brainstorming Exercise*
- Handout 2, *Exploring the Links Between Agriculture, Human Health, and Nutrition*
- Handout 3, *Short Story Assignment*

- Handout 4, *Short Story Outline*
- Handout 5, *Micronutrients*
- Handout 6, *Micronutrients Reading Guide*
- Handout 7, *"Make a Meal" Game Directions*
- Handout 8, *"Make a Meal" Player Note Sheet*
- Handout 9, *"Make a Meal" Player Information Sheet*
- Handout 10, *Quiz*
- (Optional) Handout 11, *Agriculture and Health Solutions*
- (Optional) Handout 12, *Short Story Solutions*
- Answer Key, *Micronutrients Reading Guide*
- Answer Key, *Quiz*
- *Card Game Materials: Playing Cards*
- *Card Game Materials: Player Profile Cards*

Teacher Preparation

1. Review all handouts and answer keys, and make the appropriate number of copies.
2. Review the optional extension to the lesson (Handouts 11 and 12, procedures described in the Extensions section, below). Determine whether the extension is appropriate for the class, given students' level and time available; if so, make the appropriate number of copies of Handouts 11 and 12, and plan to adjust lesson procedures accordingly.
3. Arrange the room for group work.
4. Prior to Day Three, make copies of the "Make a Meal" game materials (for a class of 30 students, six sets of playing cards and six sets of player profile cards) and cut out the playing cards and profile cards.
5. (Recommended, particularly if implementing the extension activity) Review information on the International Food Policy Research Institute's Agriculture and Health pages (www.ifpri.org > Our Work > Agriculture and Health) for additional background on the lesson topics.

Time

The complete lesson requires at least four 50-minute class periods. Options for extending or shortening the lesson are provided in the Extensions and Excerpts section, below.

Procedures Day One

1. (15 minutes) Inform students that they will spend the next several days learning about a new aspect of food security: human health and nutrition. They will begin by brainstorming connections between health and agriculture, drawing on their earlier work in the unit as they think about possible links. Divide the class into groups of three or four students, and distribute one copy of Handout 1, *Brainstorming Exercise* to each student. Ask students to discuss the questions in

their groups, taking notes on their own handout as they do so. Give students about 10–15 minutes to work.

2. (10 minutes) Bring the class back together and review the brainstorming activity. Ask groups to contribute their ideas one at a time in turn for each question, recording each idea on a whiteboard or chalkboard, until all ideas for each question have been mentioned. Ask students to add new ideas to their handouts during the class review.
3. (10 minutes) Distribute one copy each of Handout 2, *Exploring the Links Between Agriculture, Human Health, and Nutrition*; Handout 3, *Short Story Assignment;* and Handout 4, *Short Story Outline*, to each student. Explain that the first handout contains more information on the brainstorm exercise topics, while the second outlines a creative writing assignment related to these topics, which will be due on the last day of the lesson—the third handout is an outlining guide for the creative assignment, which will be due at the beginning of the next class period. Give students a few minutes to look over the assignment, and take any questions.
4. (25 minutes) Give students the remainder of the period to begin reading Handout 2; students should finish the reading before the next class period. Also ask students to begin work on the short story and to bring a completed copy of Handout 4, *Short Story Outline,* to the next class.

Day Two

1. (15 minutes) Divide the class into groups of three or four students, and ask students to take out Handouts 3 and 4 (*Short Story Assignment and Short Story Outline*). Ask students to spend about 10 minutes in their groups discussing the short story assignment—each student should explain his or her outline to the group, leaving time for other students to give feedback and ask questions. While the groups work, the instructor should circulate throughout the room to clarify any questions about the assignment and to check that each student has completed Handout 4 with appropriate preliminary ideas.
2. (35 minutes) Distribute one copy each of Handout 5, *Micronutrients*, and Handout 6, *Micronutrients Reading Guide,* to each student. Give students the remainder of the class period to work on the reading and reading guide (alone or in groups of two or three). Inform students that the completed reading guide will be due at the beginning of the next class period.
3. At the end of class, remind students that they should continue working on their short stories for homework. They will turn in their stories after presenting their work to their classmates on Day Four.

Day Three

1. Collect Handout 6, *Micronutrients Reading Guide,* as students arrive in class.
2. (20 minutes) Divide the class into groups of five or six students. Inform students that they will spend the period playing a card game

that is designed to illustrate the challenges of meeting daily macro and micronutrient needs on a limited food budget. Distribute one copy of Handout 7, *"Make a Meal" Game Directions,* to each student, and one set of playing cards and player profile cards to each group. Carefully review the game directions and reflection questions as a class, and take any questions.

3. (20 minutes) Give students about 20 minutes to play the card game, reminding students to keep the reflection questions in mind—students may wish to take some notes as they play. Each group should try to play at least two complete games.
4. (10 minutes) Bring the class back together, and lead a brief informal discussion on the game and reflection questions, focusing on students' general reaction to the game and on reflection questions 1, 2, 4, and 5.
5. At the end of class, ask students to write brief formal responses to the reflection questions for homework, to be turned in at the beginning of the next class period. Inform students that they will be taking a short quiz, covering the material in Handouts 2 and 5, at the beginning of the next class period. Finally, remind students that their completed stories (with preliminary outlines, reflection questions, and optional visuals attached) are due at the beginning of the next class period. Students will be presenting their stories to peers before handing them in.

Day Four

1. Collect student responses to the "Make a Meal" reflection questions as students arrive in class.
2. (15 minutes) Distribute on copy of Handout 10, Quiz to each student. Give students about 15 minutes to work on the quiz, and then collect all quizzes for evaluation.
3. (30 minutes) Divide the class into groups of three or four students, and ask students to take out their completed short stories and written responses to the short story reflection questions. Instruct students to take turns presenting their stories in their groups, spending about three minutes reviewing the reflection questions, about two minutes reading and discussing an excerpt from the story, and about two minutes taking questions and feedback from peers. The instructor should circulate between groups while students present, to give additional feedback and keep students on task.
4. At the end of the period, collect each student's short story and attachments (outline, reflection question responses, and optional visuals) for evaluation.

Extensions and Excerpts

Extensions: Two optional handouts are included with the lesson materials: Handout 11, *Agriculture and Health Solutions*, and Handout 12, *Short Story Solutions*. These handouts outline a sequence of two activities focused on solutions to agriculture-and-health-related problems, and may be used to add a final homework assignment (Handout 11 only) or a homework assignment and an additional in-class activity extending into a second homework assignment (Handouts 11 and 12). Instructors with extra time to devote to these activities should carry out the following steps:

1. (End of Day Four): Distribute on copy of Handout 11, *Agriculture and Health Solutions*, to each student, and ask students to complete the news analysis exercise for homework.
2. (Day Five):
   a) Spend 10–15 minutes reviewing the news analysis exercise as a class. Ask several students to summarize their articles for the group, focusing on the problem(s) and solution(s) that the article presented.
   b) Distribute one completed short story (from the assignment in Handout 3) to each student, checking that each student receives a peer's story and not their own. Also distribute one copy of Handout 12, *Short Story Solutions*, to each student.
   c) Give students the remainder of the period to begin reading their peers' stories and designing their solutions. Ask students to complete the activity for homework.

Excerpts: Instructors with less time to devote to the lesson should consider eliminating the card game (Day Two). Some instructors may wish to replace the card game with the sequence of solution-focused activities described above.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess Handout 1, *Brainstorming Exercise,* based on demonstrated effort, detail, and creativity in the student's responses to the brainstorming questions.
- Assess Handout 6, *Micronutrients Reading Guide,* based on
  - o completeness and accuracy (use the Answer Key as a guide); and
  - o the level of detail, creativity, and logical insight in the student's explanations and responses to open-ended questions.
- Assess Handout 10, *Quiz,* based on accuracy (use the Answer Key as a guide) and the student's demonstrated understanding of the lesson material in open-ended responses.
- Assess student participation in the card game based on
  - o the student's level of engagement during game play and discussion in class;
  - o completeness of the student's written responses to the game reflection questions; and
  - o the level of detail, creativity, and insight in the student's written responses to the reflection questions.

- Assess the Short Story Assignment based on
  - o story content:
    - Did the student select an appropriate thematic and geographic focus?
    - Does the story content reflect a thorough understanding of the lesson material in general, and of the thematic focus (one or more problems related to health and agriculture) in particular?
    - Does the story content reflect thorough and appropriate research on health and agriculture in the focus country?
  - o story style:
    - Did the student adhere to the length requirement?
    - Does the student write in a clear, mature style, free of spelling and grammar errors?
    - Does the student cite appropriate, credible sources used in research?
    - (Extra credit) Is the student's story exceptionally creative? Does the student make outstanding use of storytelling techniques such as suspense, imagery, character development, etc.?
    - (Extra credit) Does the student include relevant illustrations or other visuals?
  - o reflection and presentation:
    - Are the student's responses to the reflection questions complete, detailed, and insightful?
    - Do the student's responses to the reflection questions accurately reflect the story's content?
    - Did the student choose an appropriate excerpt to share with peers?
    - Does the student provide a logical, insightful explanation of the excerpt's connection to the reflection questions?
- (Optional) Assess Handout 11, *Agriculture and Health Solutions,* based on
  - o appropriateness of the student's article selection;
  - o completeness and accuracy of the student's responses to basic questions about the article (title, date, source, and content focus); and
  - o the level of detail, creativity, and logical insight in the student's evaluation of the strategy described in the article (final question).
- (Optional) Assess Handout 12, *Short Story Solutions,* based on
  - o completeness and accuracy of the student's responses to basic questions about the story (geographic and thematic focus, problem statement);
  - o completeness of the student's solution description (*what* resources will be provided, to *whom,* and *how*);

  - o the extent to which the student's solution proposal, including the assessment of potential weaknesses, reflects thoughtful, creative effort and a thorough understanding of the lesson material; and
  - o completeness and quality of the story addendum, including the student's writing style (grammar, spelling, word choice, and narrative techniques) and ability to accurately portray the solution and its consequences in the narrative form.
- Assess the student's contributions to group work and class discussion based on
  - o accuracy and appropriateness of contributions;
  - o clear and succinct statement of comments, questions, and answers;
  - o attention to other student's questions and ideas;
  - o ability to follow and promote lively, productive discussion;
  - o open-mindedness and respect for other student's backgrounds and opinions;
  - o willingness and ability to compromise and incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
  - o willingness and ability to express confusion and request clarification from other students and the instructor.

Brainstorming Exercise

In this lesson, you will learn about the connections between global and local agriculture, human health, and the nutritional status of individuals, households, and communities. The brainstorming questions below will help you start thinking about some of the topics that the lesson will address. You should respond to each question in the format that best expresses your thoughts: bullet points, short phrases, complete sentences, sketches, and diagrams are all acceptable. Try to come up with as many ideas as you can for each question. Your instructor will give you a few minutes to think about the questions on your own, and then you will discuss each question as a class before proceeding with the lesson.

Question 1: How does food production (local and global agriculture) affect your and others' health?

Question 2: How does food consumption (the food that you and others eat) affect your and others' health?

Question 3: How does your and others' health affect food production?

Question 4: How does your and others' health affect food consumption?

Exploring the Links Between Agriculture, Human Health, and Nutrition

Although human health is often treated as a separate concern from food production and consumption, food, agriculture, and health are in fact inextricably linked. Health directly affects food production and access: when people become sick, they have less energy for farming, hunting, and gathering, and money that would otherwise be spent on food may go to pay for doctors and medication instead. Similarly, the quantity and quality of food that a person consumes directly affects his or her long-term health, energy level, and susceptibility to disease.

The effects of agricultural production itself on health are perhaps less readily apparent, but they are no less important. Production practices affect food safety, disease transmission between animals and humans, and the risk of injury and illness among agricultural workers. Additionally, farmers' choices about which crops to grow affect the availability and price of certain foods in local and global markets. These mechanisms can have a profound impact on the health status of individuals, households, communities, and even nations.

This handout summarizes some of the most important linkages between food production and human health. As you read about each linkage mechanism and its effects, keep the following questions in mind:

- How important is this linkage or effect, relative to others listed in the handout (or brainstormed by the class)?
- Which global populations (geographic or demographic) are most likely to be affected by this linkage?
- Has this linkage or effect been illustrated in any recent global events? Can you think of any real-world examples?

You will have opportunities to explore these questions, and other questions related to some of the linkages and effects, as you complete the readings and activities in this lesson.

1. Health status affects agricultural productivity.

In communities that rely on manual labor for the majority of farming tasks, the health status of agricultural workers is a major factor in agricultural productivity. Individual farm workers who become sick may be unable to work for several weeks or more, compromising local crop yields and household incomes. Health shocks that occur at the national or regional scale, such as malaria or cholera epidemics, may severely restrict national or regional crop production and GDP.

GDP (Gross Domestic Product)—the value (usually expressed in dollars) of a country's annual output of final goods and services, calculated by adding up the amount of money spent on goods and services produced in the country in a given year. GDP is a common measure of overall national wealth and productivity

Chronic conditions and diseases that affect young adults in their most productive working years are particularly devastating to agricultural productivity. HIV/AIDS is one example of such a condition. Studies conducted in the late 1990s, for example, found that the AIDS epidemic was responsible for agricultural productivity losses of more than 50 percent in some African households and countries.[3]

2. Agricultural productivity affects health through its effect on the quantity of food consumed.

Hunger limits the body's ability to perform all normal functions, including defense against disease. When individuals do not consume a sufficient supply of calories and nutrients, they tend to experience more frequent, severe infections and are more susceptible to a range of common diseases. A cold or flu that would be a mere inconvenience to an otherwise healthy, well-nourished person might be life-threatening to someone also struggling with the effects of calorie deprivation. In fact, some experts have estimated that as many as half of the deaths that occur each year as a result of common diseases, such as diarrhea and malaria, could be avoided with simple improvements in food supply and nutrition (Pinstrup-Andersen, 2010).

subsistence farming—farming solely to produce food for household consumption, with no surplus for market sale

Agricultural productivity affects calorie supply in two ways. In households that rely on subsistence farming for their food supply, reduced productivity directly reduces the household food supply. In households that sell some or all of their production, reduced productivity reduces the income available to purchase an adequate supply of nutritious food in local markets. In either case, an inadequate food supply can lead to health shocks that further restrict productivity, precipitating a vicious cycle downward into ill health and poverty.

3. Agricultural production affects health through its effect on the quality and diversity of food consumed.

macronutrients—dietary components that the body requires in large quantities each day. The three major macronutrients are carbohydrates, protein, and fat

micronutrients—nutrients that the body requires in smaller daily quantities. Micronutrients include vitamins, such as vitamins A, C, D, and K, and minerals such as calcium and iron

Total calorie consumption is just one aspect of good nutrition. To maintain healthy function, the human body also requires an appropriate balance of macronutrients (carbohydrates, fats, and proteins), as well as a variety of micronutrients such as vitamins and minerals. Even in individuals who consume a sufficient total supply of calories, failure to meet these nutrient requirements compromises overall health, increases susceptibility to infection, and increases the risk of developing serious diseases and conditions ranging from chronic fatigue to blindness.

Crop production patterns determine the relative availability and prices of different foods—and, by extension, of different macro and micronutrients—in local and global markets. Products such as red meat, dairy, and fruits and vegetables contain key nutrients in much higher concentrations than do many common staple grains such as rice and wheat. However, these nutrient-rich foods may also be much more costly than basic staples, particularly if economic and technological factors encourage local farmers to focus on the production of staple crops for global export. Because fresh produce and animal products are "luxury" items for most poor consumers, even very slight fluctuations in price or supply may put them out of reach of poor households, leading to

3 United Nations Department of Economic and Social Affairs: Population Division. *The Impact of AIDS*. Chapter V: Impact on Agriculture. New York: United Nations, 2004. Available online: http://www.un.org/esa/population/publications/AIDSimpact/AIDSWebAnnounce.htm. Accessed 10 July 2012.

irreversible long-term health effects.

4. Agricultural production practices affect health through their effects on the environment.

Agricultural production has a variety of environmental consequences, many of which also have consequences for human health. Exposure to fertilizers, pesticides, and other agricultural chemicals may cause diseases and conditions ranging from simple skin irritation to chronic respiratory illness to cancer. Agricultural water management practices can affect health in several ways: Water flowing off-farm may carry chemicals or animal waste into lakes and rivers, contaminating human drinking supplies, while water flowing on-farm in open irrigation canals may attract disease agents such as malaria-bearing mosquitoes. Contamination of irrigation water with human waste or other pollutants can also affect food safety and the health of food consumers.

Livestock management practices have particularly important human health consequences. In addition to the risk mentioned above of water contamination from livestock waste, any scenario in which humans and livestock live in close proximity—as is common on many small farms—increases the risk of disease transmission between animals and humans. The World Health Organization estimates that zoonotic diseases—diseases that can be transmitted from animals to people—represent at least 60 percent of human diseases, and accounted for about 75 percent of all new diseases during the first decade of the 21st century. [4] High-profile zoonotic diseases of livestock origin include viruses such as SARS, avian influenza, and swine flu.

zoonotic disease—a disease that can be transmitted from animals to humans

5. Agricultural production practices affect health through their effects on agricultural workers.

Even as agricultural production affects health indirectly, through effects on food availability and environmental quality, farm labor itself has important consequences for the health of farm households. Agricultural work poses a range of occupational hazards, including exposure to harmful chemicals (as described above) as well as injury from equipment malfunction and exhaustion from hard manual labor. Additionally, the distribution of labor within a household may have unintended health consequences. For example, maternal and child health may be compromised if women are overcommitted to farm tasks.

Sources:

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Presentation by Per Pinstrup-Andersen at the IFPRI Policy seminar, "Understanding the Interactions between Agriculture and Health," held October 28, 2010, in Washington, D.C. Available online: http://www.

4 World Health Organization, Neglected Zoonotic Diseases. http://www.who.int/neglected_diseases/diseases/zoonoses/en/index.html. Accessed 10 July 2012.

youtube.com/watch?v=pYuwSGP-JaQ. Accessed 27 June 2012.

Presentation by Prabhu Pingali, Deputy Director, Agriculture Policy and Statistics Division, Bill & Melinda Gates Foundation, at the IFPRI policy seminar, "Linking Agriculture, Health, and Nutrition: Obstacles and Potentials," held December 7, 2010. Available online: http://www.youtube.com/watch?v=n4NaIWLabWU&feature=relmfu. Accessed 28 June 2012.

Presentation by Robert Bos at the IFPRI Policy seminar, "Understanding the Interactions between Agriculture and Health," held October 28, 2010 in Washington, DC. Available online: http://www.youtube.com/watch?v=Nt8zgU1p6Gw&feature=relmfu. Accessed 27 June 2012.

Short Story Assignment

As you have learned through your work in this lesson thus far, agriculture affects human health in a number of important ways, including effects on productivity, dietary diversity, and environmental quality. Human health can also limit agricultural productivity, leading to downward-spiraling feedbacks between poor health and low productivity.

Agriculture and health are connected in every country and community in the world; however, every community also faces unique challenges, and the connections that you have discussed may have many different manifestations. Your task in this assignment is to think deeply and creatively about how one or more of the links between agriculture and health might appear in the real world. You will compose a short fictional story (1,000–1,500 words) that illustrates the connections between agriculture and health. Read the following guidelines carefully before you begin writing:

1. **Thematic focus:** Your story must focus on one (or more) of the five major connections between agriculture and health outlined in *Handout 2, Exploring the Links Between Agriculture, Human Health, and Nutrition*. You should focus on the problems that might arise for an individual, household, or community as a result of these links; your story may or may not include the resolution of these problems. Be sure that you can precisely identify the links that your story explores and explain how you have illustrated them in context.
2. **Geographic focus:** Your story must realistically depict a specific country in Africa, Asia, or Latin America. Conduct Internet research before you begin composing your story, and during the writing process, select an appropriate country and learn about relevant aspects of its health and agriculture. In particular, you should try find answers to the following questions and incorporate them into your story:
   a. What are the most urgent health issues in this country? Look for information on recent epidemics, global health concerns such as malaria and HIV, and trends in maternal and child health.
   b. What crops do small farmers and subsistence farmers most often grow in this country?
   c. What foods do poor households consume in this country? How much access do poor households have to animal products and produce?
   d. What are farming practices like in this country? What is the balance of manual labor and mechanization? How is work distributed between members of a household? Do small farms have access to irrigation, fertilizers, and pesticides?

Be sure to cite the sources that you use in your research.

3. **Length and style:** Your story must be between 1,000 and 1,500 words in length. Use proper spelling, grammar, and punctuation. While the main purpose of this assignment is to illustrate and expand your understanding of the links between agriculture and health, exceptional creativity and writing style may also be considered in your grade!
4. **Reflection and presentation:** After you finish writing your story, answer the questions below on a separate sheet of paper (attach this sheet to your story when you hand in the assignment). You should prepare to summarize you responses in an informal three–minute oral presentation for your classmates. You should also select an excerpt from your story, no more than one or two minutes in length when read aloud, that you feel supports or illustrates your response to one or more of question (b), (c), and (d). You will read your excerpt to your classmates and explain its significance when you make your presentation.

a. Which agriculture-health links did you focus on in your story? Why did you choose to focus on these particular connections?
b. Explain how your story illustrates each of the connections that you listed.
c. How did you choose the country in which your story is set? Briefly summarize what you learned about your country's health and agriculture through your research for the assignment.
d. Which of the events, characters, or other details of your story do you think are the most fictional, i.e., the least based in your knowledge of real facts and trends? What questions would you need to answer to make these parts of your story more realistic?
e. Record the approximate location of your selected excerpt (e.g., Page 2, paragraphs 2–4). Explain how this excerpt is connected to the questions above.

5. **Visuals (extra credit):** include one or two illustrations with your story. These may be your own drawings, or they may be images that you find on the Internet during your research (in the latter case, be sure to cite your sources).

Apart from following the guidelines above, you are free to approach the assignment in any way. You may focus on one individual, a small farm or household, or an entire community. Your story may be set in the past or present, or even in the future. You should feel free to add your own creative touches, including dialogue and descriptions of characters and scenery. Have fun!

You may find the following Web sites helpful in your research:

- The U.N. Food and Agriculture Organization, www.fao.org; in particular, consult the Countries section for information on agriculture and development in specific countries.
- The World Health Organization, www.who.int; again, consult the Countries section for information on specific countries.
- The World Food Programme, www.wfp.org; consult the Countries pages or search the site for recent reports and statistics on health issues. The WFP is a particularly good source for information on nutrition and HIV/AIDS.

Short Story Outline

Use this handout to organize your thoughts as you begin work on the short story assignment. You and your instructor will use the outline to make sure that you are on track to fulfill the assignment guidelines before you are too far along in the writing process.

Thematic focus (agriculture-health links) for my story:

Why I chose this thematic focus:

Geographic focus (country) for my story:

Why I chose this geographic focus:

Key facts about my country that I already know:

Research sources that I will use to learn more about my country:

Preliminary plot summary (*who* are your protagonists; *what* will happen to them and *why*; *when* does the story take place; *how* does your plot illustrate the thematic focus—you may write a short summary in complete sentences or use bullet points):

MICRONUTRIENTS

The human body needs a range of nutrients for healthy growth, maintenance, and daily function. You are probably already familiar with the three main macronutrients, dietary components that the body requires in large quantity each day: carbohydrates, protein, and fat. Although recommendations vary, most nutritionists suggest that adults should consume about 300 grams of carbohydrates, 60–80 grams of protein, and 50–60 grams of healthy fats per day.

Micronutrients are nutrients that the body needs in much smaller quantities; however, an adequate supply of micronutrients is nonetheless essential for human health and development. Important micronutrients include minerals—such as iron, zinc, iodine, and calcium—and vitamins such as vitamin C.

Different micronutrients are found in different foods. For example, dairy products are rich in calcium, many fruits and vegetables contain vitamin C, and red meat is a good source of iron. Because micronutrients are not found in all foods, it is quite possible to meet daily macronutrient requirements while consuming a very micronutrient-poor diet. To meet micronutrient needs, humans need to consume a variety of fruits, vegetables, and animal products, in addition to basic staple grains such as rice, wheat, and maize.

During the Green Revolution of the 1960s and 1970s, sharp declines in the prices of staple grains allowed many households to begin spending a greater share of their income on meat, produce, and dairy products. However, the developments in crop breeding that occurred during the Green Revolution gave farmers a new incentive to plant new, high-yielding staple grains in lieu of "orphan" crops such as legumes and root vegetables. These changes may have reduced the availability of micronutrient-rich foods in certain areas.

Additionally, meat, dairy, and produce remain much more expensive than staple grains, and these products may still be all but inaccessible to the poorest consumers in the developing world. Micronutrient deficiency, therefore, remains an important global health problem, and may be a concern even for communities whose basic calorie and macronutrient needs are met through consumption of inexpensive staples.

According to the U.N. Food and Agriculture Organization, the World Food Programme, and the World Health Organization, the three micronutrients of greatest global health concern are iron, iodine, and vitamin A. These micronutrients are discussed in greater detail below.

Iron

Iron is an essential building block of red blood cells, which are responsible for transporting oxygen from the lungs to the muscles and other tissues in the body. An inadequate dietary supply of iron results in a reduction in the concentration of red blood cells in the body, a condition called anemia. Although anemia may have other causes—including deficiency in other micronutrients, such as vitamin B12—iron deficiency is a key factor in many cases. Symptoms of anemia include general weakness and fatigue, headaches, pale skin, and difficulty thinking and concentrating.

anemia—a condition associated with deficient or poorly functioning red blood cells, resulting in symptoms such as fatigue, pale skin, and general weakness. Anemia is often caused by inadequate dietary intake of iron or vitamin B12, both of which are used by the body in the manufacture of red blood cells

Daily iron intake requirements depend on an individual's age and gender. Nutritionists generally recommend that premenopausal women consume 15–18 mg of iron daily; recommendations are lower, 8–11 mg per day, for teenage and adult men. Although many plants, particularly legumes and leafy greens, contain high concentrations of iron, the best sources of iron are red meat, poultry, and fish. Plant-based iron is difficult for the body to absorb, and many individuals will be unable to avoid iron deficiency symptoms without consuming either meat products or iron supplements.

According to the World Health Organization, iron deficiency affects more people than any other nutritional disorder. Almost one-third of the world's population suffers from some degree of anemia, and in developing countries, it is estimated that about 50 percent of pregnant women and 40 percent of preschool-aged children are anemic. The prevalence of anemia in these countries results in widespread weakness and fatigue, limiting the productivity of the workforce and increasing the vulnerability of the population to infectious diseases and other chronic health problems.

Iodine

The human body requires iodine to regulate hormones produced by the thyroid gland, which control the body's growth, development, and metabolic rate. Iodine deficiency results in hormonal imbalances and disruption of metabolic processes. Deficiency at key stages of development can lead to mental retardation and stunting of physical growth; iodine deficiency in pregnant women often leads to mental and physical birth defects, and in extreme cases may result in the death of the fetus.

Although the impacts of iodine deficiency are most pronounced at early stages of human development, iodine requirements increase with age. Recommended intake is 40–50 mcg per day for infants, 60–100 mcg for children, and 150 mcg for adults. Pregnant women require an even higher intake, about 200 mcg per day, for healthy development of the fetus.

Iodine is present in soil in varying concentrations, and the iodine content of plant-based foods depends on the iodine content of the soil in which the food is grown. Additionally, seawater contains high concentrations of iodine; thus, seafood and ocean plants such as seaweed tend to be good iodine sources. Iodine deficiency is of greatest concern in regions where soil iodine concentrations are low—primarily mountainous and floodplain areas, where iodine has been washed out of the soil—and in inland regions where seafood is not commonly included in the diet. According to the World Health Organization, iodine deficiency is most common in Europe and Northern Africa.

Vitamin A

Vitamin A helps to maintain the health and function of the human eye, skin, and immune system. The most prominent effects of vitamin A deficiency are visual impairment and increased susceptibility to infectious disease. Young children are most severely affected; in the developing world, vitamin A deficiency often leads to partial or total childhood blindness, and it significantly increases the risk of death from common childhood diseases such as diarrhea and measles.

Children younger than nine years need 300–500 mcg of vitamin A per day for healthy growth and development. Adults need more, up to 700 mcg for women and 900 mcg for men. Requirements are highest for lactating mothers—up to 1,300 mcg per day, depending on age. [3]

Vitamin A occurs in two forms: retinol, which is found primarily in animal products such as fish oil, liver and kidney meat, milk, and eggs; and carotenoids, such as beta-carotene, which are found primarily in yellow, orange, and leafy green vegetables. As with iron, animal sources of vitamin A are generally easier for the body to absorb. Additionally, vitamin A is a fat-soluble vitamin—that is, it dissolves in fat and is stored in fatty tissues when consumed. Individuals with insufficient fat stores or consumption may therefore be at higher risk of vitamin A deficiency.

According to the World Health Organization, vitamin A deficiency is a problem in over half of all countries worldwide. Developing regions of Africa and Southeast Asia are most heavily affected. The WHO estimates that about 250 million preschool-aged children are vitamin A deficient, and that of these children, up to 500,000 per year become blind as a result of the deficiency.

Although iron, iodine, and vitamin A are the three micronutrients of greatest global health concern, there are many other micronutrients that the body needs for normal growth and function. The table on the next page lists some of the most important micronutrients and summarizes their functions, sources, and daily requirements, along with the most important effects of dietary deficiency.

3 USDA: http://fnic.nal.usda.gov/dietary-guidance/dietary-reference-intakes/dri-tables

	Function	Daily requirement (adults)	Sources	Effects of deficiency
Minerals				
Calcium	Gives strength to bones and teeth; helps to regulate blood clotting, nerve transmission, and muscle function	1,000–1,300 mg	Dairy products, dark leafy vegetables, nuts, legumes, whole grains	Bone diseases (rickets, osteomalacia, osteoporosis)
Iodine	Hormone regulation	150 micrograms; 200 micrograms for pregnant females	Seafood, plants grown in iodine-rich soil	Mental retardation, stunted growth, birth defects
Iron	Building block of red blood cells for oxygen transport	Males: 8–11 mg; females: 15–18 mg	Red meat, poultry, seafood, legumes, leafy greens	Anemia (fatigue, headache, pale skin, poor concentration)
Zinc	Metabolism, wound healing, vision	Males: 11 mg; females: 8 mg; Pregnant/lactating: 11–13 mg	Meat, seafood, eggs, whole grains	Delayed wound healing, reduced immunity, retarded growth
Fat-soluble vitamins				
Vitamin A	Vision, skin health, immunity	Males: 900 mcg; females: 700 mcg	Retinol: fish oil, liver and kidney meat, milk, eggs; carotenoids: yellow, orange, and leafy green vegetables	Blindness, reduced immunity
Vitamin D	Regulate calcium and phosphorous metabolism	15 mcg	Sunlight; small amounts in egg yolks and liver	Bone diseases
Vitamin E	Antioxidant (protects skin and tissues), immunity	15 mcg	Vegetable oil, seeds, nuts, soybeans, leafy greens, whole grains	Reduced immunity, accelerated tissue breakdown (aging)
Vitamin K	Blood clotting, bone strength	Males: 120 mcg; females: 90 mcg	Leafy green vegetables	Susceptibility to bruising, severe bleeding
Water-soluble vitamins				
Folic acid (folate)	Formation of genetic material, cells, and protein	400 mcg	Leafy green vegetables, liver, eggs, beets, orange juice, lima beans, whole grains	Anemia, reduced nutrient absorption, susceptibility to prolonged bleeding
Vitamin B12	Formation of genetic material (DNA, RNA) and protein	2.4 mcg	Animal products (organ meats, red meat, poultry, eggs, milk)	Anemia, nerve disorders
Vitamin C	Tissue maintenance, metabolic function, assists in iron absorption	Males: 90 mg; females: 75 mg	Fresh fruits (especially citrus, strawberries), fresh vegetables (especially Brussels sprouts, peas, asparagus)	Weak tissues (bleeding from skin and gums); muscle weakness; reduced immunity; reduced brain, nerve function

Adapted from World Food Programme. Food Quality Control: Food Nutritional Quality. http://foodquality.wfp.org/FoodNutritionalQuality/tabid/113/Default.aspx. Accessed 29 June 2012.

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World Food Programme. Food Quality Control: Food Nutritional Quality. http://foodquality.wfp.org/FoodNutritionalQuality/tabid/113/Default.aspx. Accessed 29 June 2012.

World Health Organization. Nutrition: Micronutrients. http://www.who.int/nutrition/topics/micronutrients/en/. Accessed 29 June 2012.

Micronutrients Reading Guide

Use the information in Handout 4 to answer the following questions. Write your responses on a separate sheet of paper.

True or false:

- The human body needs smaller daily quantities of micronutrients than macronutrients: __________
- Micronutrients are less important than macronutrients for healthy growth and function of the human body: __________

Explain why it is possible to meet daily macronutrient and calorie needs without meeting micronutrient needs, and describe a daily diet that would meet macronutrient and calorie needs but not micronutrient needs.

How did the Green Revolution affect poor households' access to micronutrients?

List the three micronutrients of greatest global health concern:

An individual with an iron deficiency would exhibit which of the following symptoms? (Circle all that apply):

- Bone disease
- Fatigue
- Bleeding from skin and gums
- Pale skin
- Difficulty concentrating

Which of the following symptoms would suggest a vitamin A deficiency? (Circle all that apply):

- Night blindness
- Headaches
- Delayed wound healing
- Reduced immunity
- Nerve disorders

Make a list of nutrient deficiencies that you might expect to see in an individual who consumes few or no animal products:

Make a list of nutrient deficiencies that you might expect to see in an individual who consumes little or no produce (fresh fruits and vegetables):

Rank the following demographic groups in order from most to least susceptible to damaging nutrient deficiencies: adult woman, pregnant woman, adult man, child. Write a few sentences explaining why you ranked the groups as you did (there may be more than one correct answer).

What are the main sources of iron and vitamin A in your diet? How much do these foods cost?

"Make a Meal" Game Directions

In this lesson, you have learned that providing a sufficient number of calories per person is just one aspect of ensuring global food security. Healthy, food-secure individuals will also require an appropriate balance of carbohydrates, fat, and protein in their diets, and will need to consume a variety of fruits, vegetables, and animal products to meet daily micronutrient needs. For a poor household, it may be quite possible to meet calorie needs through consumption of low-cost staples, while falling far short of the recommended intake of protein, iron, vitamins, and other key macro and micronutrients. Although they might not be "hungry" in the most basic sense, this household would still be considered food-insecure.

You and your classmates will now have a chance to experience the challenge of meeting daily dietary needs with limited food options, through a card game called "Make a Meal." In the game, you will be assigned a role as a child, male or female adult, or elderly person. You will trade and draw cards representing common staple and luxury foods, with the goal of acquiring a hand that meets the dietary needs for your role. Although the game is, of course, a much-simplified representation of the decisions that would face a food-insecure individual or household, it should nonetheless help you to better understand how different foods contribute to a healthy diet, and to appreciate the difficulty of assembling such a diet when certain foods are expensive or rare.

Carefully review the rules and directions below before your group begins play. Also review the questions for reflection and discussion at the end of this handout; you will be asked to respond to these questions after you have played a few rounds of the game. Good luck!

"Make a Meal" Game Directions

Materials

- Playing cards: total of 54 cards listing calories and nutrients for the following food items: Corn (six cards), Rice (six cards), Wheat (six cards), Soybeans (six cards), Sorghum (four cards), Cassava (four cards), Sweet Potato (four cards), Eggs (two cards), Milk (two cards), Beef (two cards), Poultry (two cards), Fish (two cards), Oranges (two cards), Tomatoes (two cards), Spinach (two cards), Peanuts (two cards)
- Player profile cards: five cards listing daily calorie and nutrient requirements for the following player roles: Child (five years), Adult man, Adult woman, Pregnant woman, Elderly; one blank card to be filled in by an extra player choosing their own role. Profile cards also indicate the number of playing cards that each role should draw at the beginning of the game.

Setup

1. Check that the set of playing cards and playing profile cards is complete as described in the Materials section
2. Assign each player to a role. Role assignment may be left to player choice or may be accomplished by random drawing of player profile cards. Regardless of how roles are assigned, each player should take and hold the player profile card associated with their role, and review the nutrient requirements for their role. If there are five or fewer players, each player will take a pre-printed profile card. If there are six players, one player will have a

blank card, which may be filled in with nutrient requirements for the player's choice of role.

3. Shuffle the stack of playing cards, and have each player draw the correct number of cards for their role from the stack (players will draw four to seven cards, depending on their role; the exact number is indicated on each profile card). Players should NOT show one another their cards. Leave the remaining playing cards in a stack, face down, where all players can reach them.

Rules of Play

1. One "round" of play consists of one turn for each player (procedures for each turn are described below). At the beginning of the game and again before each new round, all players have three minutes to tally the nutrients in their hand on their player sheet and assess their nutrient needs. The game ends after three complete rounds.
2. Player turns occur in the following order: Adult man, Adult woman, Elderly, Pregnant woman, Child
3. Each turn includes the following steps:
   a. The player whose turn it is (Player A, for the purposes of this explanation) picks up the top card from the stack of cards in the center of the table and places it face up on the table for all players to see.
   b. All players have one minute to review their cards and consider which if any cards in their hand they would be willing to trade for the card on the table. Player A may choose to declare any nutrient needs at this time (e.g., the player may state "For the group's information, I am low on iron" while other players are considering their trades).
   c. After one minute, each player has a chance to offer Player A a trade for the card on the table. Player A then do may do any of the following:
      i. Accept the trade offered by another player (Player B), in which case Player B takes the card on the table and gives Player A the card (or cards) offered in the trade. Player A then chooses one card to discard from their hand, which they place at the bottom of the card stack.
      ii. Accept none of the trades and add the card on the table to their hand, discarding a different card from their hand and placing it at the bottom of the card stack.
      iii. Leave their hand as it as, and allow play to proceed to the next turn.

   Note that players may make unbalanced trades (e.g., one egg card for two rice cards) and that this will cause the number of cards held by a player to change throughout the game.
3. After three complete rounds of play, all players conduct a final tally of the nutrients in their hands. If a player has met their needs for a particular nutrient as outlined on their player profile card, they receive points for that nutrient. Points are assigned as outlined below, and the player with the most points is declared the winner of the game.

Calories:	1 point	Iron:	4 points
Carbohydrate:	2 points	Zinc:	2 points
Protein:	3 points	Vitamin A:	5 points
Fat:	3 points	Vitamin C:	5 points
Calcium:	5 points		

"Make a Meal" Reflection and Discussion Questions

1. Which player role won your group's game (if you played multiple games, which role(s) won the most games)?

2. Which player role had the most difficult time meeting nutrient needs in your group?

3. What factors in the game gave the winning roles their advantage? What factors prevented certain roles from winning? Think about the pros and cons of playing each role, and summarize them below:
   a. Child
   b. Adult man
   c. Adult woman
   d. Pregnant woman
   e. Elderly

4. What particular food items seemed to be critical to winning the game? Think about items that you asked for frequently or that winning players always seemed to have in their hands.

5. Which nutrient requirements were the hardest to meet in the game? Why were these requirements hard to meet? Drawing on your work in this lesson, describe some potential health consequences of failing to meet these requirements.

6. Describe one insight that you felt you gained from playing the game.

7. Describe one way in which you feel the game does not accurately represent real-world challenges related to food security, nutrition, and health. What would you change or add to make the game more realistic?

"Make a Meal" Player Note Sheet

Use this note sheet to keep track of your progress through the three rounds of "Make a Meal." Before each round, record the cards in your hand, the quantity of each nutrient from each card, and your total supply of each nutrient. Calculate your *deficit* by subtracting your role's requirement for a nutrient from your supply of that nutrient (negative numbers indicate that you are not meeting your nutrient requirements). Perform a final tally (space is provided on the back of the sheet) at the end of the game. Note: Some player roles will not need to use all of the card columns; use the extra columns if you gain cards in an uneven trade.

	Round One									
	Card 1	Card 2	Card 3	Card 4	Card 5	Card 6	Card 7		Total	*Deficit*
Calories										
Carb.										
Protein										
Fat										
Calcium										
Iron										
Zinc										
Vit. A										
Vit. C										

	Round Two									
	Card 1	Card 2	Card 3	Card 4	Card 5	Card 6	Card 7		Total	*Deficit*
Calories										
Carb.										
Protein										
Fat										
Calcium										
Iron										
Zinc										
Vit. A										
Vit. C										

"Make a Meal" Player Note Sheet (Continued)

Use this note sheet to keep track of your progress through the three rounds of "Make a Meal." Before each round, record the cards in your hand, the quantity of each nutrient from each card, and your total supply of each nutrient. Calculate your *deficit* by subtracting your role's requirement for a nutrient from your supply of that nutrient (negative numbers indicate that you are not meeting your nutrient requirements). Perform a final tally (space is provided on the back of the sheet) at the end of the game. Note: Some player roles will not need to use all of the card columns; use the extra columns if you gain cards in an uneven trade.

	Round Three									
	Card 1	Card 2	Card 3	Card 4	Card 5	Card 6	Card 7		Total	*Deficit*
Calories										
Carb.										
Protein										
Fat										
Calcium										
Iron										
Zinc										
Vit. A										
Vit. C										

	Final Tally									
	Card 1	Card 2	Card 3	Card 4	Card 5	Card 6	Card 7		Total	*Deficit*
Calories										
Carb.										
Protein										
Fat										
Calcium										
Iron										
Zinc										
Vit. A										
Vit. C										

"Make a Meal" Player Information Sheet: Nutrient Profiles of Selected Foods

	Calories	Carb. (g)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Zinc (mg)	Vit. A (mcg)	Vit. C (mg)
Corn	350	80	10	5	10	0	0	80	20
Rice	400	90	10	5	40	0	0	0	0
Wheat	350	75	15	0	30	5	5	0	0
Soybeans	300	20	30	15	170	10	0	15	5
Sorghum	500	100	15	5	40	5	0	0	0
Cassava	350	80	5	0	30	1	0	5	80
Sweet Potatoes	350	80	10	0	150	5	0	7,000	80
Eggs	200	0	20	15	40	5	5	60	0
Milk	300	30	15	15	550	0	0	50	0
Beef	200	0	20	15	15	5	5	0	0
Poultry	150	0	15	10	5	1	1	0	0
Fish	100	0	20	5	15	1	1	0	0
Oranges	150	40	0	0	120	0	0	0	160
Tomatoes	60	10	5	0	40	0	0	300	50
Spinach	5	0	0	0	30	1	0	280	10
Peanuts	200	5	10	20	80	5	5	0	0

"Make a Meal" Player Information Sheet: Nutrient Profiles of Selected Foods

	Calories	Carb. (g)	Protein (g)	Fat (g)	Calcium (mg)	Iron (mg)	Zinc (mg)	Vit. A (mcg)	Vit. C (mg)
Corn	350	80	10	5	10	0	0	80	20
Rice	400	90	10	5	40	0	0	0	0
Wheat	350	75	15	0	30	5	5	0	0
Soybeans	300	20	30	15	170	10	0	15	5
Sorghum	500	100	15	5	40	5	0	0	0
Cassava	350	80	5	0	30	1	0	5	80
Sweet Potatoes	350	80	10	0	150	5	0	7,000	80
Eggs	200	0	20	15	40	5	5	60	0
Milk	300	30	15	15	550	0	0	50	0
Beef	200	0	20	15	15	5	5	0	0
Poultry	150	0	15	10	5	1	1	0	0
Fish	100	0	20	5	15	1	1	0	0
Oranges	150	40	0	0	120	0	0	0	160
Tomatoes	60	10	5	0	40	0	0	300	50
Spinach	5	0	0	0	30	1	0	280	10
Peanuts	200	5	10	20	80	5	5	0	0

Quiz

Questions 1–3 refer to a malaria outbreak in a small farming community.

1. Explain how the outbreak is likely to affect agricultural productivity.

2. Suggest at least one way that agricultural systems or production practices might have contributed to the outbreak.

3. The outbreak spreads to a neighboring community, which is similar to the first community but which receives regular food aid shipments from an international humanitarian organization. Will the effects of the outbreak be different in the second community? Explain.

4. Match each of the following micronutrients to the symptoms of its deficiency:

a. Iron	A. Bone diseases (rickets, osteoporosis, etc)
b. Vitamin A	B. Stunted growth, mental retardation
c. Calcium	C. Vision and skin problems, reduced immunity
d. Vitamin C	D. Tissue weakness, bleeding from skin and gums
e. Iodine	E. Fatigue, weakness, pale skin (anemia)

5. List at least two micronutrient deficiencies that would be associated with a completely vegetarian diet.

6. List at least two micronutrient deficiencies that would be associated with a diet that includes few fruits and vegetables.

Agriculture and Health Solutions (Optional Assignment)

In this lesson, you have learned that problems with health and problems with agriculture are often closely linked. A lack of diversity in crop production can lead to a lack of diversity in diets, contributing to micronutrient deficiencies. Poor water management practices can increase the presence of mosquitoes and other disease vectors, and overapplication of fertilizers and pesticides can compromise environmental quality and worker safety. Finally, low agricultural productivity can set off a cycle of negative consequences for both agriculture and health; chronic hunger increases susceptibility to disease and further reduces workers' capacity to raise productivity above a bare subsistence level.

Thus far, you have focused on the problems that agriculture can create for health and vice versa. You will now have the opportunity to research one or more solutions to these problems. Begin by visiting the International Food Policy Research Institute's "Agriculture and Health" topics page (www.ifpri.org > Our Work > Agriculture and Health). Spend some time exploring the information and stories on the page, and follow the links to read news stories and learn about health-related programs and projects within IFPRI.

Ultimately, you will need to find a press release or other short news article that discusses efforts to leverage agriculture-health connections to address food insecurity and health-related problems. For example, you might find stories about helping farmers grow micronutrient-rich crops, or about improving water management to reduce the spread of malaria. You may decide to move beyond the content available from IFPRI by conducting a general Internet search for news articles on agriculture and health, but the IFPRI page is a good starting point for learning about common health-related development strategies and for finding articles from credible sources.

Once you have settled on a news story, read it carefully and answer the questions below (type or write on a separate sheet). Print your news story to turn in with your responses.

Article title:

Article date:

Source:

What country(s) or region(s) does the article focus on?

What issue(s) related to health and agriculture does the story discuss?

Describe the solutions or interventions that the article discusses. What action is being taken, by whom, and for whose benefit?

Do you think that the solution or intervention will be effective in addressing the issues discussed? Why or why not? Explain your response thoroughly, and be creative in thinking about both the strengths and weaknesses of the strategy as presented in the article.

Short Story Solutions (Optional Assignment)

The *Short Story* assignment asked you—and each of your classmates—to create a short story illustrating one or more problems that might confront an individual, household, or community as a result of the links and feedbacks between agriculture and health. In this assignment, you will have the opportunity to propose a solution to the problems presented in one of your classmates' stories. You should draw on your work in this lesson and unit, and in particular on the *Agriculture and Health Solutions* news analysis assignment, as you think about appropriate strategies. You may conduct additional research if you wish, but be sure to cite any sources that you use.

Your instructor will provide you with a story written by one of your classmates. Read the story carefully, and then respond to the following questions (type or write your answers on a separate sheet):

What is the story's geographic focus (in what country or region is the story set)?

What is the story's thematic focus (i.e., what issues related to health-agriculture links are illustrated in the story)?

State the main problem confronted by the characters in the story, using no more than two sentences.

Describe a strategy to address the problem that you described above. Be specific about what assistance or resources you would provide, to whom and how (i.e., through what organizations or channels).

Describe at least one potential weakness of your strategy (how could your strategy fail or go wrong?).

Write a short (around 500 words) epilogue or addendum to your classmate's story, describing the implementation of your strategy and its effect on the characters and problems in the original story. Consider the weaknesses that you described above as you write; although you may certainly have your strategy succeed, you may wish to include some caveats or reference to unintended side effects!

Answer Key to Handout 6 (Micronutrients Reading Guide)

Use the information in Handout 4 to answer the following questions. Write your responses on a separate sheet of paper.

True or false:

- The human body needs smaller daily quantities of micronutrients than to macronutrients: **TRUE**
- Micronutrients are less important than macronutrients for healthy growth and function of the human body: **FALSE**

Explain why it is possible to meet daily macronutrient and calorie needs without meeting micronutrient needs, and describe a daily diet that would meet macronutrient and calorie needs but not micronutrient needs.

Micronutrients are not contained in all foods; in fact, some vitamins and minerals are only contained in very specific foods, such as dairy products or fruits and vegetables of a particular color. By contrast, all foods contain calories, and most contain some amount of carbohydrate, protein, and fat. Imagine that your diet consisted exclusively of plain cheeseburgers—the buns would provide ample carbohydrates, while the cheese and meat would provide protein, fat, and some mineral micronutrients such as calcium and iron. However, you would certainly be deficient in most vitamins, which are found in the highest concentrations in fresh fruits and vegetables.

How did the Green Revolution affect poor households' access to micronutrients?

The Green Revolution had both positive and negative effects on micronutrient access. As prices for staple foods (rice, wheat, maize, etc.) fell, households had more spare income to spend on "luxury" foods such as fruits, vegetables, meat, and dairy. However, the advances in crop breeding for staple grains that occurred during the Green Revolution gave farmers an incentive to plant more staple grains at the expense of other crops such as local vegetables and legumes. This latter effect reduced the availability of micronutrient-rich foods in local markets.

List the three micronutrients of greatest global health concern:

Iron, iodine, vitamin A

An individual with an iron deficiency would exhibit which of the following symptoms? (Circle all that apply):

- Bone disease
- **Fatigue**
- Bleeding from skin and gums
- **Pale skin**
- Difficulty concentrating

Which of the following symptoms would suggest a vitamin A deficiency? (Circle all that apply):

- **Night blindness**
- Headaches
- Delayed wound healing
- **Reduced immunity**
- Nerve disorders

Make a list of nutrient deficiencies that you might expect to see in an individual who consumes few or no animal products:

Iron, calcium, zinc, vitamin B12, vitamin A (retinol)—students should list at least four appropriate deficiencies.

Make a list of nutrient deficiencies that you might expect to see in an individual who consumes little or no produce (fresh fruits and vegetables):

Vitamin A, vitamin C, vitamin E, vitamin K, folic acid—students should list at least four appropriate deficiencies.

Rank the following demographic groups in order from most to least susceptible to damaging nutrient deficiencies: adult woman, pregnant woman, adult man, child. Write a few sentences explaining why you ranked the groups as you did (there may be more than one correct answer).

Answers may vary slightly, but pregnant women and children should be listed as more susceptible than adults. Pregnant women have higher nutrient requirements that children or adult men or women, while children are going through key stages of development during which a small micronutrient deficiency may have severe and permanent health consequences.

What are the main sources of iron and vitamin A in your diet? How much do these foods cost?

Answers will vary. Students should list appropriate food sources of iron (meat, legumes, leafy greens) and vitamin A (fish oil, liver and kidney meat, milk, eggs, leafy green and yellow/orange vegetables), and should evaluate their cost relative to less nutrient-rich foods such as pasta, bread, and other grain products. The relative costs, of course, will depend on the student's context and the specific items being compared—a fast–food hamburger may be less expensive than a loaf of artisan bread!

Answer Key to Handout 10 (Quiz)

Questions 1–3 refer to a malaria outbreak in a small farming community.

1. Explain how the outbreak is likely to affect agricultural productivity.
   Agricultural productivity is likely to decline as a result of the outbreak, because sick farmers will be unable to work.

2. Suggest at least one way that agricultural systems or production practices might have contributed to the outbreak.
   Answers may vary. The most acceptable answer, suggested in Handout 2, would be that open irrigation canals attracted mosquitoes, which transmitted the disease to people. Students may also suggest that livestock could attract mosquitoes or other disease vectors.

3. The outbreak spreads to a neighboring community, which is similar to the first community except in that it receives regular food aid shipments from an international humanitarian organization. Will the effects of the outbreak be different in the second community? Explain.
   The effects of the outbreak are likely to be less severe in the community receiving food aid, because better nutrition will make people more able to resist and recover from the disease.

4. Match each of the following micronutrients to the symptoms of its deficiency:
   a, E; b, C; c, A; d, D; e, B

a. Iron	A. Bone diseases (rickets, osteoporosis, etc)
b. Vitamin A	B. Stunted growth, mental retardation
c. Calcium	C. Vision and skin problems, reduced immunity
d. Vitamin C	D. Tissue weakness, bleeding from skin and gums
e. Iodine	E. Fatigue, weakness, pale skin (anemia)

5. List at least two micronutrient deficiencies that would be associated with a completely vegetarian diet.
   Answers may vary. Acceptable answers include iron, vitamin B12, vitamin A, and zinc. A vegan diet (no eggs or dairy) might contribute to a calcium or vitamin D deficiency.

6. List at least two micronutrient deficiencies that would be associated with a diet that includes few fruits and vegetables.
   Answers may vary. Acceptable answers include vitamin A, vitamin K, folic acid, and vitamin C.

Corn
(2 cups)

Calories: 350
Carbohydrate: 80g
Protein: 10g
Fat: 5g
Calcium: 10mg
Iron: 0mg
Zinc: 0mg
Vitamin A: 80mcg
Vitamin C: 20mg

Rice
(2 cups)

Calories: 400
Carbohydrate: 90g
Protein: 10g
Fat: 5g
Calcium: 40mg
Iron: 0mg
Zinc: 0mg
Vitamin A: 0 mcg
Vitamin C: 0 mg

Wheat
(100g wheat flour)

Calories: 350
Carbohydrate: 75g
Protein: 15g
Fat: 0g
Calcium: 30mg
Iron: 5mg
Zinc: 5mg
Vitamin A: 0mcg
Vitamin C: 0 mg

Corn
(2 cups)

Calories: 350
Carbohydrate: 80g
Protein: 10g
Fat: 5g
Calcium: 10mg
Iron: 0mg
Zinc: 0mg
Vitamin A: 80mcg
Vitamin C: 20mg

Rice
(2 cups)

Calories: 400
Carbohydrate: 90g
Protein: 10g
Fat: 5g
Calcium: 40mg
Iron: 0mg
Zinc: 0mg
Vitamin A: 0 mcg
Vitamin C: 0 mg

Wheat
(100g wheat flour)

Calories: 350
Carbohydrate: 75g
Protein: 15g
Fat: 0g
Calcium: 30mg
Iron: 5mg
Zinc: 5mg
Vitamin A: 0mcg
Vitamin C: 0 mg

Corn
(2 cups)

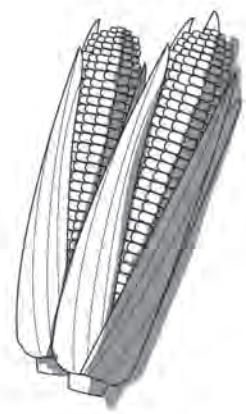
Calories: 350
Carbohydrate: 80g
Protein: 10g
Fat: 5g
Calcium: 10mg
Iron: 0mg
Zinc: 0mg
Vitamin A: 80mcg
Vitamin C: 20mg

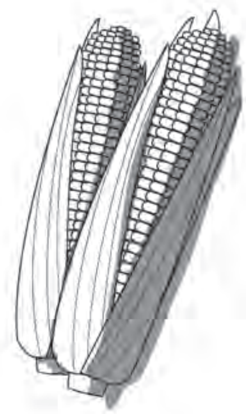
Rice
(2 cups)

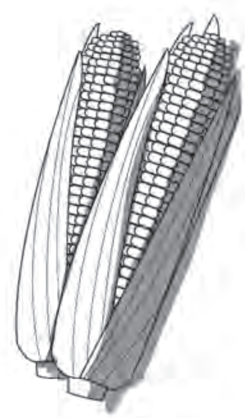
Calories: 400
Carbohydrate: 90g
Protein: 10g
Fat: 5g
Calcium: 40mg
Iron: 0mg
Zinc: 0mg
Vitamin A: 0 mcg
Vitamin C: 0 mg

Wheat
(100g wheat flour)

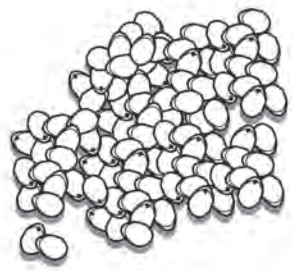
Calories: 350
Carbohydrate: 75g
Protein: 15g
Fat: 2g
Calcium: 30mg
Iron: 4mg
Zinc: 3mg
Vitamin A: 2mcg
Vitamin C: 0 mg

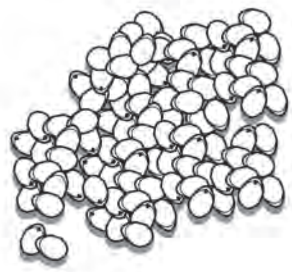






Soybeans (1 cups) Calories: 300 Carbohydrate: 20g Protein: 30g Fat: 15g Calcium: 170mg Iron: 10mg Zinc: 0mg Vitamin A: 15mcg Vitamin C: 5mg	**Sorghum** (1 cup flour) Calories: 500 Carbohydrate: 100g Protein: 15g Fat: 5g Calcium: 40mg Iron: 5mg Zinc: 0 mg Vitamin A: 0 mcg Vitamin C: 0 mg	**Cassava** (1 cup) Calories: 350 Carbohydrate: 80g Protein: 5g Fat: 0g Calcium: 30mg Iron: 1mg Zinc: 0 mg Vitamin A: 5mcg Vitamin C: 80mg
Soybeans (1 cups) Calories: 300 Carbohydrate: 20g Protein: 30g Fat: 15g Calcium: 170mg Iron: 10mg Zinc: 0mg Vitamin A: 15mcg Vitamin C: 5mg	**Sorghum** (1 cup flour) Calories: 500 Carbohydrate: 100g Protein: 15g Fat: 5g Calcium: 40mg Iron: 5mg Zinc: 0 mg Vitamin A: 0 mcg Vitamin C: 0 mg	**Cassava** (1 cup) Calories: 350 Carbohydrate: 80g Protein: 5g Fat: 0g Calcium: 30mg Iron: 1mg Zinc: 0 mg Vitamin A: 5mcg Vitamin C: 80mg
Soybeans (1 cups) Calories: 300 Carbohydrate: 20g Protein: 30g Fat: 15g Calcium: 170mg Iron: 10mg Zinc: 0mg Vitamin A: 15mcg Vitamin C: 5mg	**Sweet Potato** (2 cups)) Calories: 350 Carbohydrate: 80g Protein: 10g Fat: 0 g Calcium: 150mg Iron: 5mg Zinc: 0mg Vitamin A: 7000mcg Vitamin C: 80mg	**Sweet Potato** (2 cups)) Calories: 350 Carbohydrate: 80g Protein: 10g Fat: 0 g Calcium: 150mg Iron: 5mg Zinc: 0mg Vitamin A: 7000mcg Vitamin C: 80mg





Eggs
(2 eggs)

Calories: 200
Carbohydrate: 0g
Protein: 20g
Fat: 15g
Calcium: 40mg
Iron: 5mg
Zinc: 5mg
Vitamin A: 60mcg
Vitamin C: 0 mg

Milk
(2 cups)

Calories: 300
Carbohydrate: 30g
Protein: 15g
Fat: 15g
Calcium: 550mg
Iron: 0 mg
Zinc: 0mg
Vitamin A: 50mcg
Vitamin C: 0 mg

Beef
(100g)

Calories: 200
Carbohydrate: 0 g
Protein: 20g
Fat: 15g
Calcium: 15mg
Iron: 5mg
Zinc: 5mg
Vitamin A: 0 mcg
Vitamin C: 0 mg

Poultry
(100g)

Calories: 150
Carbohydrate: 0 g
Protein: 15g
Fat: 10g
Calcium: 5mg
Iron: 1mg
Zinc: 1mg
Vitamin A: 0 mcg
Vitamin C: 0 mg

Fish
(100g codfish)

Calories: 100
Carbohydrate: 0g
Protein: 20g
Fat: 5g
Calcium: 15mg
Iron: 1mg
Zinc: 1mg
Vitamin A: 0mcg
Vitamin C: 0mg

Oranges
(2 orange)

Calories: 150
Carbohydrate: 40g
Protein: 0g
Fat: 0g
Calcium: 120mg
Iron: 0 mg
Zinc: 0 mg
Vitamin A: 0mcg
Vitamin C: 160mg

Tomatoes
(2 large tomato)

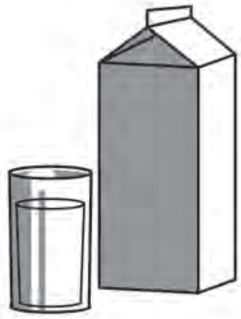
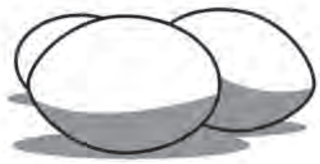
Calories: 60
Carbohydrate: 10g
Protein: 5g
Fat: 0g
Calcium: 40mg
Iron: 0mg
Zinc: 0mg
Vitamin A: 300mcg
Vitamin C: 50mg

Spinach
(1 cup)

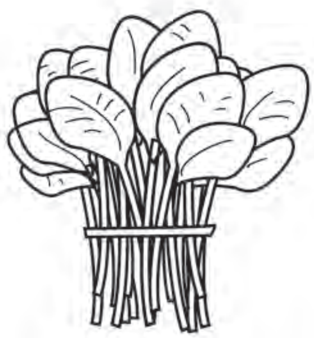
Calories: 5
Carbohydrate: 0g
Protein: 0g
Fat: 0g
Calcium: 30mg
Iron: 1mg
Zinc: 0 mg
Vitamin A: 280mcg
Vitamin C: 10mg

Peanuts
(1/4 cup)

Calories: 200
Carbohydrate: 5g
Protein: 10g
Fat: 20g
Calcium: 80mg
Iron: 5mg
Zinc: 5mg
Vitamin A: 0 mcg
Vitamin C: 0 mg




Child (5 years)

Calories: 1500
Carbohydrate: 200g
Protein: 75g
Fat: 45g
Calcium: 600mg
Iron: 6mg
Zinc: 5mg
Vitamin A: 450mcg
Vitamin C: 30mg
**Note: iron and zinc requirements assume moderate bioavailability, i.e. a combination of plant and animal sources*

Pregnant woman

Calories: 2500
Carbohydrate: 345g
Protein: 125g
Fat: 70g
Calcium: 1200mg
Iron: 60mg
Zinc: 10mg
Vitamin A: 800mcg
Vitamin C: 55mg
**Note: iron and zinc requirements assume moderate bioavailability, i.e. a combination of plant and animal sources*

Adult man

Calories: 2700
Carbohydrate: 370g
Protein: 135g
Fat: 75g
Calcium: 1000mg
Iron: 15mg
Zinc: 7mg
Vitamin A: 600mcg
Vitamin C: 45mg
**Note: iron and zinc requirements assume moderate bioavailability, i.e. a combination of plant and animal sources*

Elderly (65+ years)

Calories: 2000
Carbohydrate: 275g
Protein: 100g
Fat: 55g
Calcium: 1300mg
Iron: 15mg
Zinc: 5mg
Vitamin A: 600mcg
Vitamin C: 45mg
**Note: iron and zinc requirements assume moderate bioavailability, i.e. a combination of plant and animal sources*

Adult woman

Calories: 2200
Carbohydrate: 300g
Protein: 110g
Fat: 60g
Calcium: 1000mg
Iron: 30mg
Zinc: 5mg
Vitamin A: 500mcg
Vitamin C: 45mg
**Note: iron and zinc requirements assume moderate bioavailability, i.e. a combination of plant and animal sources*

Calories:
Carbohydrate:
Protein:
Fat:
Calcium:
Iron:
Zinc:
Vitamin A:
Vitamin C:
**Note: iron and zinc requirements assume moderate bioavailability, i.e. a combination of plant and animal sources*

Lesson Four

Economic Access to Food
Part One: Food Price Dynamics

Organizing Questions

- What factors influence food prices, and how can we explain their influence using economic principles?
- What accounts for the correlation between the prices of various food commodities and differences in the price of a single commodity between countries and regions?
- How and why are producer, wholesale, and consumer prices different?
- How can we begin to predict the effects of a change in food prices on food security?
- How might governments control food prices in response to a food security problem, and what additional problems might they encounter or create in doing so?

Introduction

This lesson focuses on one of several factors that govern economic access to food: local and global trends in food prices. Students explore key fundamentals of food price dynamics, including principles of supply and demand; price correlations by commodity and region; the interaction between retail, wholesale, and producer prices; and the food security implications of the food price dilemma. The lesson introduces new economic vocabulary and includes brainstorming, graph analysis, news analysis, and group discussion activities.

Objectives

In this lesson, students will

- explore and apply the basic microeconomic principles of supply and demand in the context of food price fluctuation and variation;
- recognize the positive correlation between poverty and agriculture in the developing world and its implications for food security;
- acquire and use a vocabulary of basic economic terms;
- work cooperatively in groups to understand complex ideas; and
- access and critically analyze news articles related to food price trends.

Materials

- Handout 1, *Viewing Guide: Gregory and Jeff Raikes Video Clip*
- Handout 2, *Introduction to Food Price Dynamics*
- Handout 3, *Food Price Dynamics Point #1*
- Handout 4, *Food Price Dynamics Point #2*
- Handout 5, *Food Price Dynamics Point #3*

- Handout 6, *Food Price Dynamics Point #4*
- Handout 7, *Food Price Dynamics Point #5*
- Handout 8, *Exercise: Food Price News Analysis*
- Handout 9, *Quiz*
- Answer Key, *Viewing Guide: Gregory and Jeff Raikes Page Video Clip*
- Answer Key, *Food Price Dynamics Point #5 (Graph Analysis sample answers)*
- Answer Key, *Quiz*
- DVD, *clip from Gregory Page and Jeff Raikes, "Improving Food Security in the 21st Century: What Are the Roles for Firms and Foundations?" Lecture delivered at Stanford University, February 10, 2011. Complete lecture available online—instructor may choose to show additional content or to make the entire video available to students outside of class.*

Advanced Materials

The following materials may be used to supplement the lesson for advanced students and students with an economics background. The *Extensions and Excerpts* section provides suggestions for using these materials in class.

- Handout 10, *Lecture Summary, "Managing Food Price Volatility." (Brown, Tyler, "Experts debate path to 'food security,'"* The Stanford Daily, *27 May 2011).*
- Handout 11, *Reading Guide: Lecture Summary, "Managing Food Price Volatility"*
- Handout 12, *"Household-level impacts of high food prices." Excerpted from "The State of Food Insecurity in the World: 2011." UN Food and Agriculture Organization. Rome: FAO, 2011.*
- Handout 13, *Reading Guide: "Household-level impacts of high food prices."*
- Handout 14, *"Trade Controls Buffer Domestic Prices." Images excerpted from "The State of Food Insecurity in the World: 2011." UN Food and Agriculture Organization. Rome: FAO, 2011.*
- Handout 15, *Writing Exercise*
- Answer Key, *Reading Guide: Lecture Summary, "Managing Food Price Volatility"*
- Answer Key, *Reading Guide: "Household-level impacts of high food prices"*

Equipment

- Whiteboard or chalkboard
- Video projector
- Internet-ready computers

Teacher Preparation

1. Review all handouts listed in the *Materials* section, and make the correct number of copies (one per student, unless otherwise indicated).
2. Arrange the room for group work throughout the lesson.

3. Prior to Day One, set up and test video projector.
4. Prior to Day One, watch the video clip and review the viewing guide and answer key. Recommended: Watch the Greg Page and Jeff Raikes' lecture in its entirety to develop a complete understanding of the context for the clip.
5. Prior to Day Two, prepare Internet-ready computers for student research.
6. Review the *Advanced Materials* section and the suggestions for using these materials in class in the *Extensions and Excerpts* section. Determine whether any of the advanced materials are appropriate, given students' backgrounds and the time available for this lesson. Note: instructors will benefit from reviewing the advanced materials even if these materials are not used in class; Handouts 10 and 12, in particular, provide useful background and perspective on the topic of food price economics.

Time

The complete lesson requires at least three 50-minute class periods. Students also complete a homework assignment prior to Day One. Suggestions for extending or shortening the lesson are provided in the *Extensions and Excerpts* section, on page 157.

Procedures Before Day One

Explain to students that they will spend the next two class periods learning about another important factor in food security: food prices. Distribute one copy each of Handouts 2–7 to each student. Assign Handouts 2 and 3 as homework. Ask students to read the handouts carefully, and to complete the exercise at the end of Handout 3.

Day One

1. (5 minutes) Remind students that they will begin their exploration of food prices by watching an excerpt from a lecture by Gregory Page, CEO of the international agricultural firm Cargill. In the clip, Page argues that food insecurity is primarily an issue of prices and economic access rather than one of food availability. Distribute one copy of Handout 1, *Viewing Guide: Greg Page Video Clip* to each student. Instruct students to take notes on the guide as they watch (in particular, draw students' attention to the space provided on the guide for recording unfamiliar vocabulary terms). Give students a few minutes to review the guide before playing the video.
2. (5 minutes) Play the clip from Page's lecture.
3. (20 minutes) Give students a few minutes to refine their notes on the *Viewing Guide*, and then discuss the video:
   a. Briefly review any unfamiliar vocabulary; ask students to note definitions on the *Viewing Guide.*
   b. Review the *Viewing Guide* questions, using the Answer Key as a guide and focusing on Page's closing statements (the importance of paying farmers an adequate price). Be sure that students

understand what it means for the price to be "adequate": Farmers must be able to purchase seed and other inputs for the coming year, in addition to household essentials.

c. If time allows, invite students to comment briefly on one or more of the discussion questions included on the Answer Key (suggestion: begin with question 7 and work back, keeping the discussion primarily focused on price issues).

d. Call on a few students to suggest possible questions for the speaker.

4. (10 minutes) Divide the class into groups of three students. Ask students to take out Handout 3, *Food Price Dynamics Point #1*, and to review the handout exercises as a group. Each student should take a few minutes to share the factors that he or she brainstormed; students should add new factors from group members' lists to their own notes on the handout.
5. (10 minutes) Ask students to divide Handouts 4, 5, and 6 within their groups, with each student choosing one handout to focus on. Instruct students to begin reading the handout associated with their point; students should finish reading and complete the brainstorming exercise on their handout for homework. Students should bring their work to the next class period and be prepared to present a brief summary of their work to their group.

Day Two

1. (15 minutes) Ask students to reassemble in their groups from Day One, and to share with their groups what they learned from their individual reading. Each student should speak for about 5 minutes, spending about half of the time summarizing the content of his or her handout, and the remaining time discussing the extension question at the end of the handout with their group. All group members should take notes on the presentation and write a brief response to the extension question on the appropriate handout.
2. (35 minutes) Instruct students to spend the remainder of the period reading Handout 7 and completing the brainstorming and graph analysis exercises. Encourage students to continue to work in their groups and to discuss the exercises and questions with their peers. The instructor should circulate among the groups to resolve confusion and add to discussion; use the Answer Key as a guide for the graph analysis questions.
3. At the end of the period, instruct students to complete Handout 7 and to make any revisions or additions to Handouts 2–6, for homework. Students will have a short quiz on the material in these handouts at the beginning of the next class period, after which Handouts 2–7 will be collected for evaluation.

Day Three

1. (10 minutes) Distribute Handout 9, *Quiz.* Give students about 10 minutes to take the quiz.
2. (40 minutes) Ask students to reassemble in their groups from Days

One and Two. Distribute one copy of Handout 8, *Food Price News Analysis*, to each student. Direct students (still in groups of three) to Internet-ready computers, and give students the remainder of the class period to complete the news analysis activity. All group members will work on the same article, but each group member should complete his or her own copy of the handout. Each group should print a copy of their article, if possible, to turn in.

3. At the end of the period, collect Handouts 2–7 from each student (be sure that students attach any extra sheets on which they have written answers or notes). If students would like additional time to work on the news analysis activity, the instructor may choose to collect the activity at the beginning of the next class period; otherwise, students should turn in the activity along with the handout packet.

Extensions and Excerpts

Extensions: Instructors who feel that the advanced materials are appropriate for their class are encouraged to:

- Distribute the supplementary handout, "Trade Controls Buffer Domestic Prices," during the group discussion at the beginning of Day Two. Ask students to discuss this handout in addition to the material in Handout 7 and to share their insights with the class.
- Assign the supplementary reading, "Household-level impacts of high food prices" (FAO), in addition to or in lieu of Handout 7 (the supplementary reading covers much of the same material, but in greater depth and using slightly more advanced terminology and economic reasoning).
- Assign the supplementary reading, "Managing Food Price Volatility" (*Stanford Daily*) in addition to Handout 7.
- Assign the optional writing exercise as homework at the end of Day Two. This exercise encourages students to synthesize topics covered in this lesson by defending certain food price policy prescriptions. Instructors may choose to assign all or part of the writing exercise. Note: Reading guides for both supplementary readings are included; instructors may assign the reading guide as optional or required, or simply ask students to complete the reading and prepare to contribute questions or comments in class discussion, depending on the level of challenge desired.

Excerpts: Instructors with less time to devote should consider eliminating the Food Price News Analysis exercise, concluding the lesson after administering the Quiz on Day Three.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess Handout 1, *Viewing Guide: Greg Page Video Clip*, based on
  - o accuracy of the student's responses (use the *Answer Key* as a guide);
  - o the student's attention to unfamiliar terms and demonstrated

commitment to seeking accurate definitions during class discussion;
- o the student's demonstrated ability to formulate creative, appropriate questions for the speaker; and
- o the neatness, organization, and thoroughness of the student's notes, demonstrating ability to take useful notes while absorbing the video material.

- Assess Handouts 3–7, *Food Price Dynamics Points #1–5*, based on
  - o the level of detail, creativity, and logical insight in the student's responses to brainstorming questions (note that for Handouts 4, 5, and 6, each student will have responded to the brainstorming questions for only one of the three points);
  - o the student's demonstrated ability to logically and creatively apply the handout material in answering the extension questions that follow Points #2–4 (all students should answer all three extension questions);
  - o the level of accuracy, detail, and creativity in the student's responses to the graph analysis questions in Handout 7 (use the *Answer Key* as a guide); and
  - o the student's overall effort in interpreting the handout material and contributing to their group's understanding.
- Assess student Handout 8, *Food Price News Analysis Exercise,* based on
  - o the student's choice of appropriate, relevant articles from credible news sources;
  - o Completeness and accuracy of the student's responses to the questions on the exercise handout;
  - o the student's demonstrated ability to accurately distill key points from a news article, summarize conclusions concisely in their own words, and critically assess the strength of the author's statements;
  - o the student's demonstrated ability to connect the article's topic and content to the lesson material; and
  - o the student's attention to unfamiliar vocabulary and demonstrated commitment to seeking accurate definitions.
- Assess students' participation in group work and class discussion throughout the lesson based on
  - o accuracy and appropriateness of contributions;
  - o clear and succinct statement of comments, questions, and answers;
  - o attention to other students' questions and ideas;
  - o ability to follow and promote lively, productive discussion;
  - o open-mindedness and respect for other students' backgrounds and opinions;
  - o willingness and ability to incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
  - o willingness and ability to express confusion and request clarification from other students and the instructor.

The following are suggestions for assessing advanced student work in this lesson:

- Assess student work on Handout 11, *Reading Guide: Lecture Summary, "Managing Food Price Volatility,"* based on
  - o the level of detail, creativity, and logical insight in the student's responses to the reading guide questions (note that for most questions, students are not expected to arrive at answers that match those given in the answer key);
  - o the extent to which the student's responses connect Timmer's ideas to concepts covered in this lesson;
  - o the student's attention to unfamiliar terms and demonstrated commitment to seeking accurate definitions; and
  - o the student's initiative in seeking out additional resources on this topic (award extra credit as appropriate to students who consult the resources suggested on the reading guide and incorporate points from those sources into written responses and class discussion).
- Assess student work on Handout 13, *Reading Guide: "Household-level impacts of high food prices,"* based on
  - o Accuracy of student responses (use the *Answer Key* as a guide);
  - o the level of detail, creativity, and logical insight in the student's responses (award extra credit for responses that go beyond the stated question to suggest implications for food security policy and objectives);
  - o the extent to which the student's responses connect the contents of the brief to concepts covered in this lesson;
  - o the student's demonstrated ability to interpret complex or technical statements in their own words, using appropriate vocabulary, examples, and analogies; and
  - o the student's attention to unfamiliar terms, and demonstrated commitment to seeking accurate definitions.
- Assess student work on Handout 14, *"Trade Controls Buffer Domestic Food Prices,"* based on
  - o the level of detail, creativity, and logical insight in the student's written responses to the handout questions and contributions to class discussion;
  - o the extent to which the student applies concepts from the lesson to explain and explore the price trends shown in the graphs; and
  - o the student's appropriate use of vocabulary from the lesson in their graph analysis.
- Assess student work on Handout 15, *Writing Exercise,* based on
  - o Content:
    - Does the student adopt and defend a clear stance on the question?
    - Does the student make a logical, creative, and insightful argument in defense of his or her stance?

- Does the student's argument consider caveats and alternate perspectives?
- Does the student draw on material presented in the lesson to support his or her ideas?
- Does the student use the points listed on the assignment handout to shape his or her response, addressing a majority of the points in reasonable depth?

o Style:

- Does the student organize his or her points in a logical, cohesive argument, making effective use of topic sentences and concluding statements?
- Does the student accurately employ vocabulary and expressions from the lesson, as appropriate?
- Does the student employ accurate spelling and correct grammar?
- Does the student adhere to the length guideline for the question?

Viewing Guide: Gregory Page and Jeff Raikes Video Clip

In this lesson, you will learn about the various factors that influence the price of food, and about the powerful connections between food prices and food security. Food prices are one of many factors that determine economic access to food. These economic factors help to explain why hunger persists even in regions of high crop productivity, where physical availability of food is not an issue.

To help you begin thinking about the economics of food security, you will watch a brief clip from a lecture by Gregory Page, CEO of the international agricultural firm Cargill. Page highlights the surprising extent of malnourishment in regions of food surplus, and he touches on several economic factors, including food prices, that he believes may be contributing to the problem.

Read through the following questions before watching the video clip. Try to record the answers to these questions as you watch. Note unfamiliar terms and any other questions in the spaces provided at the end of the guide. Your teacher will collect your notes at the end of class.

1. Undernourishment is most prevalent in ________________ , where ______ percent of children are chronically malnourished.

2. Undernourishment in this region mentioned above is primarily an issue of inadequate __________________________.

3. The two countries with the highest numbers of malnourished people are _________ and ___________.

4. Why is the answer to (3) surprising? To what factors does Page attribute the extent of malnourishment in these two countries?

5. According to the UN Food and Agriculture databases—and Cargill's calculations—"extinguishing hunger" would require _____________ tons of whole grain, about one-sixth the amount we currently use for ________________.

6. Page suggests that our failure to extinguish hunger is an issue not of ____________ famine but of __________________________.

7. According to Page, the "fundamental ingredient of sustainable agriculture" is _________________________.

Unfamiliar terms:

Questions about the lecture/for the speaker:

Introduction to Food Price Dynamics

Although we all know that some food products cost more than others, we may not stop to consider why. We buy things that we like to eat and can afford. If the price of a product rises, we may substitute another, and if the price of a product falls, we may make a greater effort to fit it into our diets. But what accounts for these fluctuations? And how can we explain consistent differences in the prices of similar products—for example, the fact that chicken is nearly always cheaper than beef?

These questions have profound food security implications. Food prices affect the distribution of food and may severely restrict economic access to food, even in regions where the physical availability of food is high. In other words, even if it appears that there is plenty of food to go around, food prices may limit calorie intake in the world's poorest households, while richer households consume more than they really need.

food price dynamics—a general term for the patterns of movement in food prices (e.g., increases and decreases) and the forces that drive them.

Many leading economists have devoted their careers to the study of food price dynamics. Much of their work is theoretical and complex; however, its essential foundations are easy to grasp. This lesson will lead you through an investigation of several basic facts of food price economics. The five key points listed below will help you understand why food prices rise, fall, and differ between products, and how the dynamics of food prices affect global food security.

Point #1: Food prices are governed by supply and demand.

Point #2: The prices of major food commodities tend to be correlated.

Point #3: The same product may have many different prices in different countries and regions.

consumer price—the price paid for a good or service by its consumer.

producer price—the price received for a good or service at the initial sale by its producer

Point #4: Consumer prices are often higher than producer prices.

Point #5: To fully appreciate the food security implications of a change in food prices, we must consider the effects of the change on both producers and consumers.

This lesson guide covers these points one at a time; however, the points are closely related, so you should be sure that you understand each point before moving on to the next. Group activities, assignments, and supplementary materials provided by your teacher will help you refine your understanding.

Food Price Dynamics Point #1

microeconomics—the branch of economics that focuses on the behavior and welfare of individual economic actors (households, companies, consumers, etc.). A second branch, **macroeconomics**, focuses on the behavior and welfare of a national or regional economy as a whole

Food prices are governed by supply and demand.

According to the fundamental theory of microeconomics, the price of any good is set according to the supply of the good balanced against the demand *for* the good. This principle applies not only to food, but also to all other goods that are bought and sold. Supply and demand can affect price in four basic ways, as follows:

- If demand *increases*, price increases.
- If demand *decreases*, price decreases.
- If supply *increases*, price decreases.
- If supply *decreases*, price increases.

Figure 1 summarizes these effects.

	Supply	Demand
Increase	$--	$++
Decrease	$++	$--

Figure One: Supply, Demand, and Price

The interactions between supply, demand, and price should seem intuitive after a little reflection. Think of supply and demand as reflections of producers' costs of production and consumers' willingness to pay. Now consider how shifts in the cost of production and consumers' willingness to pay will affect supply, demand, and price.

1. *An increase in consumer willingness to pay increases price*: Suppose that each consumer has a fixed budget that he or she plans to spend on a certain food product, such as corn. Now suppose that for some reason each consumer's budget, or willingness to pay, increases. Willingness to pay could increase for a number of different reasons—for example, an increase in income, a decrease in the prices of other necessities, or a popular news article touting the health benefits of corn.

   Given their increased willingness to pay, consumers will want to purchase more corn; however, unless suppliers can increase production very quickly, there will not be enough corn available to meet the new demand. Suppliers, seeking to maximize their profit, will respond by raising the price of corn until consumers can just afford the current available quantity with their new, larger corn budgets.

profit—a producer's net earnings, i.e., the difference between total **revenue** (income from sales) and total costs of production

2. *A decrease in consumer willingness to pay decreases price*: Suppose as in the previous example that each consumer has a fixed budget for purchasing corn, but now suppose that budget decreases, for example, due to a decrease in income, an increase in the prices of other basic necessities, or a news article about food-borne illnesses linked to corn products. Given their shrinking budgets, consumers will buy less corn; producers, eager to sell as much as possible before the crop spoils, will lower the price of corn until consumers can afford to purchase the available quantity with their new, smaller budgets.

3. *A decrease in cost of production increases supply and lowers price*: Suppose that each corn producer has a fixed budget for producing corn. This budget must cover all the producer's costs, including inputs (water, seed, and fertilizer), labor, machinery, etc. Now suppose that one or more of those costs declines—perhaps as a result of new technology or favorable weather. The decline in costs allows producers to grow more corn within their total budget—they may be able to hire more workers, plant more seed, purchase more and better fertilizer, etc. Thus, the average cost of producing each bushel of corn falls, and producers can lower the price that they charge consumers without sacrificing profit.

   In fact, if production increases while consumer willingness to pay remains constant, producers must lower the price in order to persuade consumers to buy up the new surplus (similar to example #2 above). Note, therefore, that producers will choose to increase their production only if the decrease in average cost exceeds the decrease in price required to sell the surplus. If producers will lose more in price cuts than they gain in cost savings, they will simply pocket the cost savings and continue to produce the same quantity as before.

average cost—a producer's cost per unit including all **fixed costs** (costs for inputs that are purchased once, regardless of production quantity, such as land and machinery) and all **variable costs** (costs for inputs purchased in quantities that vary according to the total production quantity, such as labor, seed, and fertilizer. *Example*: If a farmer produces 1,000 bushels of corn, and pays $2,000 for land and machinery plus $2 per bushel for labor, seed, and fertilizer, his or her average cost is ($2,000 + 2*1,000)/1,000 = $4 per bushel.

4. *An increase in the cost of production decreases supply and increases price*: Suppose as in the previous example that each producer has a fixed budget for producing corn, but now suppose that producers' costs increase, perhaps due to unfavorable weather, stricter environmental regulations, or higher wage demands from workers. The increase in costs will force producers to cut back on production in order to stay within their budgets. The average cost of producing each bushel of corn will rise, and producers will charge a higher price in order to maintain their profits.

Note that if the cost increase is significant, consumers may not be willing to pay a price high enough to make up the difference—that is, if price rises too steeply, many consumers will simply choose not to purchase corn. In this case, corn farmers will lose money, and they may switch to growing different crops for which costs are lower or consumer willingness to pay is higher. We will address this "substitution effect" in greater detail in the next section.

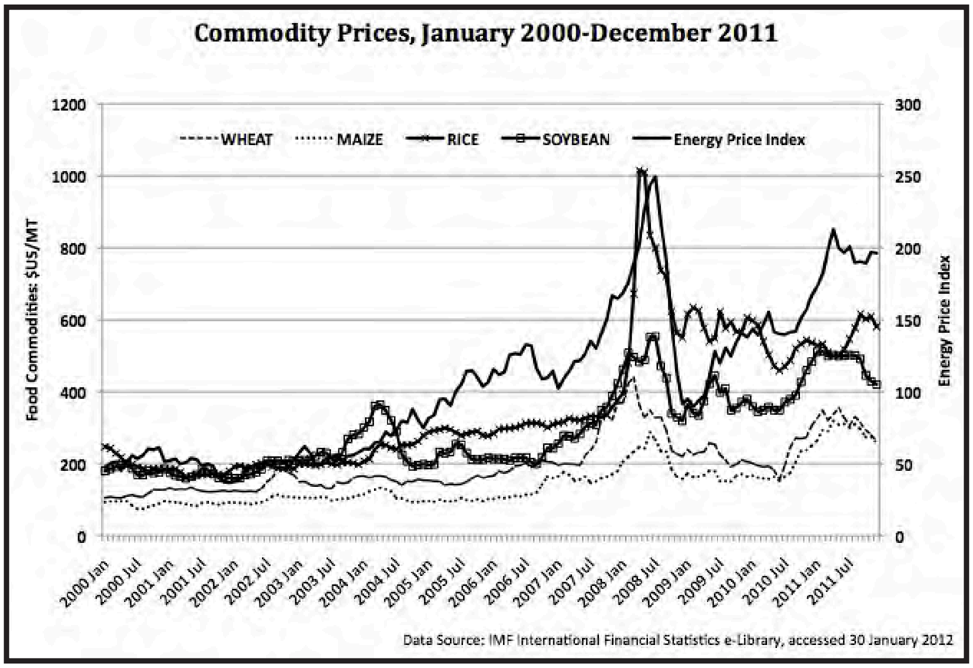
Activity: Fill in the boxes with factors that could affect producers' costs of food production and consumers' willingness to pay for food. The examples above mention several such factors; you may include those in your list, but be sure to think of several of your own, as well. Be specific, and brainstorm as many factors as you can. Note the overall effect of price below each box.

Costs of production will increase if:	**Costs of production will decrease if:**
Effect on price:	**Effect on price:**
Willingness to pay will increase if:	**Willingness to pay will decrease if:**
Effect on price:	**Effect on price:**

Food Price Dynamics Point #2

The prices of major food commodities tend to be correlated.

The graph below displays monthly prices for several major food commodities during the first decade of the 21st century. Study the graph carefully.



Before moving on to read the explanation of Point #2, describe the trends that you see in the graph. Consider sudden increases and decreases, similarities and differences between commodities, etc. There is no "right" answer—record any observations that you find interesting! Write in the space below, or use a separate sheet if you need additional space.

In the preceding exercise, you may have noticed that the prices of these commodities tend to go up or down at the same time—in other words, the prices are correlated. To explain the correlation, we will return to the final example from Point #1.

correlated—two phenomena (such as changes in the prices of two commodities) are correlated if they usually accompany or parallel one another. Note that this does not imply that one phenomenon causes the other to occur, i.e., correlation does not imply causation.

Consider once again a scenario in which the costs of corn production rise, but now assume that the increase in costs pushes the price of corn very high, so that the price of even one bushel exceeds many consumers' total corn budgets. These consumers may decide not to buy corn at all, and will look for a similar product to buy instead—wheat, for example.

Consumers who decide to substitute wheat for corn will shift their entire corn budget into wheat, substantially increasing their willingness to pay for wheat. We can refer to the first example from Point #1 to predict the results of this shift—with a fixed wheat supply, the spike in demand will cause a corresponding spike in the price of wheat.

Meanwhile, willingness to pay for corn will fall substantially. The second example in Point #1 tells us that this reduction in willingness to pay should lead producers to lower their prices again, moderating the cost-driven price spike. These feedbacks will continue until the prices of corn and wheat balance—i.e., until consumers are no longer motivated to change their consumption patterns. In this new equilibrium, both corn and wheat prices will be higher than before the cost increase.

Note that the preceding analysis addresses short-term effects. If the increase in production costs is specific to corn (i.e., does not reflect an increase in the price of land, fertilizer, or other inputs common to many agricultural products) and is sustained over the long term, farmers will choose to plant wheat instead of corn. With this shift, the supply of wheat will increase to meet the new, higher demand, and the price of wheat will begin to return to its former level.

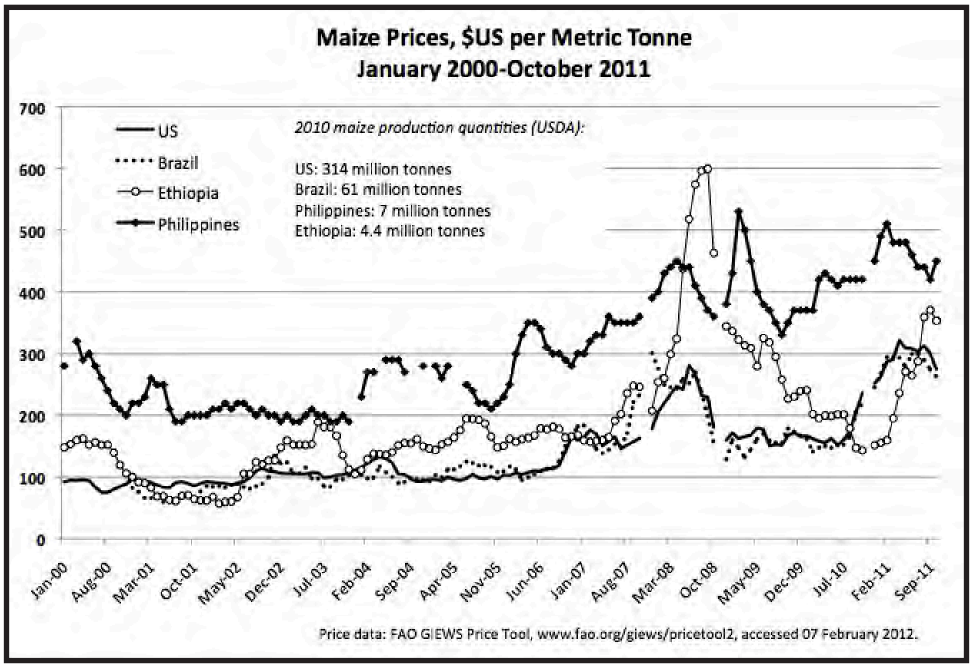
Permanent differences in production cost explain the wide variation in the prices of different food products—beef, for example, is much more expensive to produce than poultry, because cows require more land and feed than chickens. Because most major grain commodities require similar inputs in production, large shifts in the relative prices of these commodities are usually temporary. However, regional differences in production cost or willingness to pay may lead to substantial variation in regional prices. The next section addresses this issue in greater depth.

The graph at the beginning of this section also includes an Energy Price Index: a measure of the overall cost for energy products such as oil, natural gas, and biofuels. Why do you think that this index is included on the graph? Are energy prices correlated with food commodity prices? How could you explain the correlation or noncorrelation?

FOOD PRICE DYNAMICS POINT #3

The same product may have many different prices in different countries and regions.

The graph below displays monthly maize prices in several countries during the first decade of the 21st century. Study the graph carefully.



Before moving on to read the explanation of Point #3, describe the trends that you see in the graph. Consider sudden increases and decreases, similarities and differences between regional prices, etc. Note the production data given at the top of the graph, and think about how the data might explain or relate to price trends. There are no "right" answers—record any observations that you find interesting! Write your observations and your responses to the brainstorming prompts below on a separate sheet.

Maize prices may be low in the United States because (list factors/ conditions in the United States):

Maize prices may be high in the Philippines because (list factors/ conditions in the Philippines):

When you have listed all the factors that you can think of on your own, read through the list of suggestions on the next page. Make sure that you understand the explanation associated with each factor.

The following factors may help to explain country-to-country variation in food prices. Keep in mind that this list is by no means exhaustive, and that some, all, or none of these factors might be relevant to any particular scenario.

Factors that affect the local cost of production

- Local environment: Fertile soils and regular, moderate rainfall reduce farmers' costs for inputs such as water and fertilizer.
- Local technology: Farmers who have access to labor saving equipment, efficient irrigation systems, and improved seed varieties will have lower production costs.
- Local input costs: Land, labor, water, and other inputs may be more expensive in some countries than in others, depending on their relative scarcity.
- Local policies: For example, local regulations might increase farmers' costs by restricting their use of fertilizers and pesticides or by dictating the minimum wage that they can pay their workers.

Note that where production costs—and by extension, prices—are lower, farmers will generally produce more. The production numbers given on the graph reflect this principle (annual production is highest in the United States and Brazil, where the price trend is lowest).

Factors that affect local willingness to pay

- Local income: Consumers' food budgets will be smaller in countries where per capita incomes are low and poverty is prevalent.
- Local customs and tastes: In some countries, religious or social customs may reduce demand for certain food products—in India, for example, religious taboos against eating beef restrict demand for food products.
- Local alternative uses for the product: If other industries in the country use agricultural products as inputs to production, their demand may drive prices higher—especially if firms in these industries can afford to pay higher prices than the average consumer. Demand for corn from the U.S. ethanol industry is one good example of this effect.

Other factors

- Trade: If a country imports a food product, factors such as shipping costs, trade restrictions (taxes on imports or exports, for example), and production costs in the supplying country will affect prices. If a country exports a large share of their domestic production, the resulting in-country shortage may drive prices up.
- Exchange rates: Note that the prices in the graph above are given in U.S. dollars. If a country's currency increases or decreases in value relative to the dollar, the price in dollars may rise or fall suddenly while the price in local currency remains constant.

Examine the 2007–2009 period on the price graph. While prices for maize increased in all four countries during this period, the spikes in Ethiopia and the Philippines were much more dramatic than those in the United States and

Brazil. How could you explain this difference in the magnitude of the price spike? Consider how the factors listed above might affect price stability in addition to absolute price.

FOOD PRICE DYNAMICS POINT #4

Consumer prices are often higher than producer prices.

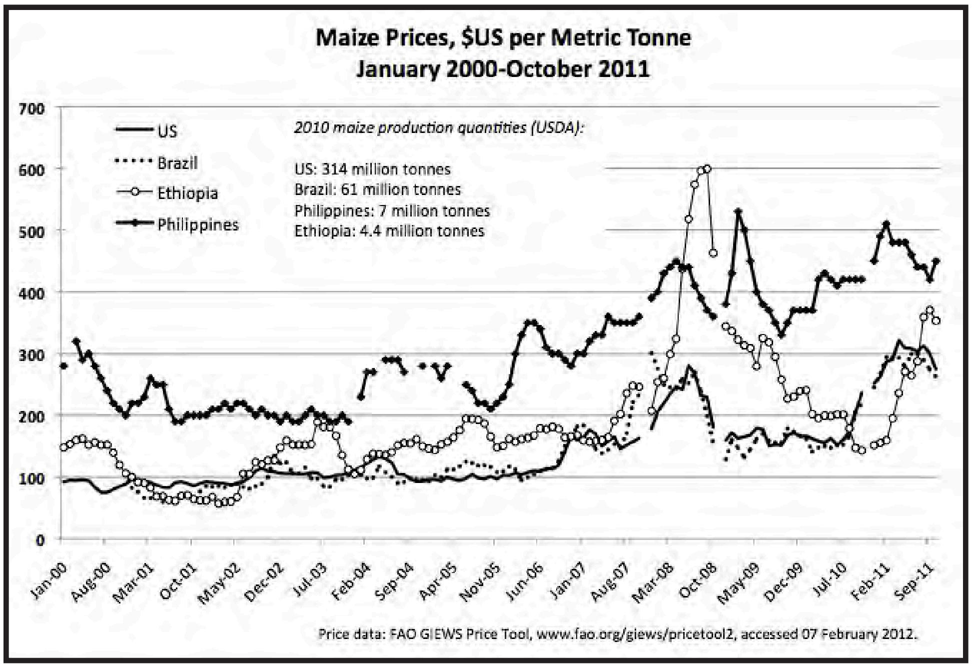
The consumer price of a product is the price paid for the product by its consumer, sometimes called the retail price. The producer price is the price received for the product by its producer.

wholesaler—a middleman between consumer and producer. Usually, a wholesaler buys goods in large quantities from producers, and then sells them to retailers, who make the final sale to consumers

wholesale price—the price received for a good or service by a wholesaler (usually, the price paid by the retailer)

In many cases, producers do not sell their products directly to consumers. Instead, they sell in large quantities to middlemen, or wholesalers, who then distribute the product to retailers, who make the final sale to the consumer. For example, a wholesaler might purchase bananas from a farmer in Central America and sell them to your local grocery store, which in turn sells them to you. In this case, the producer price is the price that the producer receivers from the wholesaler. The price that the store pays the wholesaler is called the wholesale price, and the price that you pay at the store is the retail or consumer price.

The graph below shows retail, wholesale, and producer maize prices in the Philippines during the period between 2000 and 2011. Study the graph carefully.



Before moving on to read the explanation of Point #4, describe the trends that you see in the graph. Consider sudden increases and decreases, similarities and differences between retail, wholesale, and producer prices, etc. There is no "right" answer—record any observations that you find interesting! Write your response in the space below or on a separate sheet if you need more space.

In the preceding exercise, you probably noticed that the retail price is consistently higher than the wholesale price, which in turn is higher than the producer price. You may also have noticed that the three prices are closely correlated. How might you account for these observations? Brainstorm some possible explanations, and write a logical guess in the spaces below (or on a separate sheet, if you need more space). When you have listed all the factors that you can on your own, read through the suggestions on the next page.

Retail, wholesale, and producer prices are all correlated because:

Retail prices are higher than wholesale prices, which are higher than producer prices, because:

Food Price Dynamics Point #5

To fully appreciate the food security implications of a change in food prices, we must consider the effects of the change on both producers and consumers.

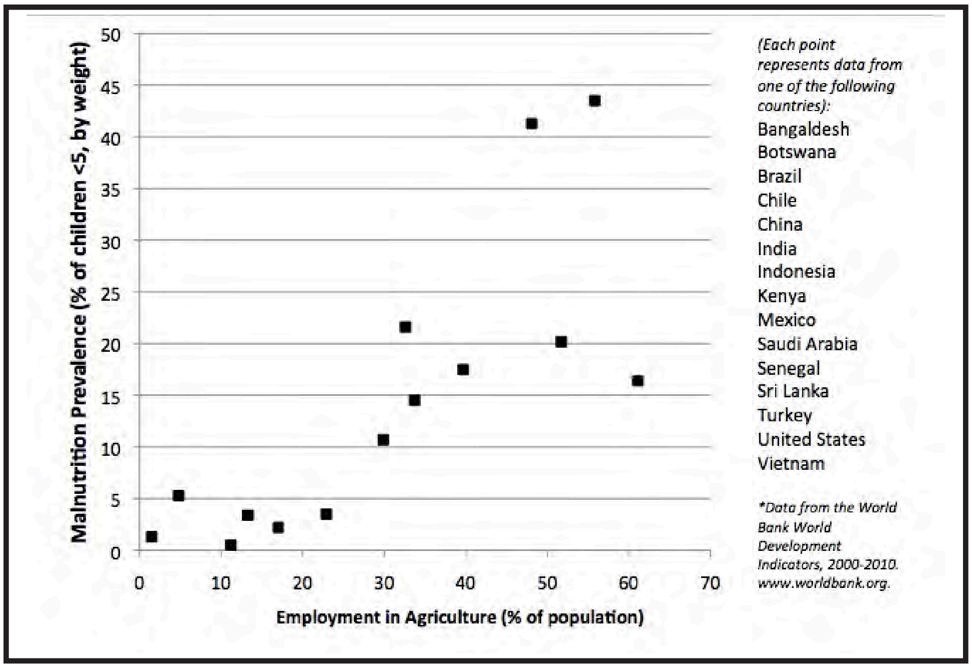
In responding to the question at the end of the previous section, you might suggest that a sharp spike in retail prices would have a negative food security impact—and you would be correct. Higher retail prices make it difficult for poor consumers to afford enough food. Similarly, a decline in retail prices (holding producer and wholesale prices constant) should have a positive food security impact, as any decline in retail prices makes food more affordable.

Let's now consider a slightly more complex scenario. Suppose that a new laborsaving technology results in a sharp drop in local maize production costs for farmers in the United States. The drop in production costs motivates farmers to increase their production and leads to a drop in producer, wholesale, and retail prices. Because the United States accounts for over one-third of the world's corn production and over one half of world corn exports, the decline in U.S. costs and prices affects the price of corn in many other countries around the world. Wholesalers buying U.S. corn for international shipment will now face lower producer prices in the United States; as their "costs of production" for U.S. corn fall, they will purchase more U.S. corn and pass the savings on the international retailers, who will in turn buy more corn and charge a lower price to consumers.

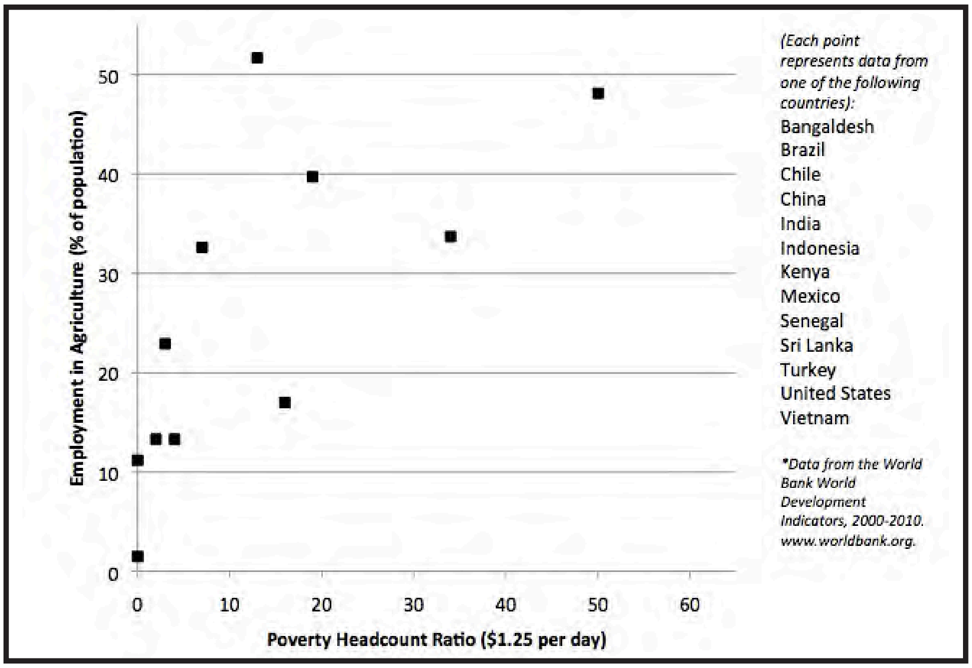
Before reading the conclusion to this scenario, describe how you think the cost and price decrease will affect food security in the developing world. Write your thoughts in the space below, or on a separate sheet if you need additional space.

As international wholesalers and retailers shift toward buying more corn from the United States, they will necessarily purchase less corn from other producers, including farmers in developing countries. Non-U.S. farmers who do continue to sell corn will face pressure to lower their prices to match the new, lower U.S. producer price.

Study the graphs below carefully, keeping the preceding insight in mind. Answer the questions on the next page (use a separate sheet if you need additional space); note that you are asked to revise your thoughts regarding the food security impact of the U.S. price decrease.



Malnutrition Prevalence (% of children <5, by weight)
50
45
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
Employment in Agriculture (% of population)
(Each point represents data from one of the following countries):
Bangaldesh
Botswana
Brazil
Chile
China
India
Indonesia
Kenya
Mexico
Saudi Arabia
Senegal
Sri Lanka
Turkey
United States
Vietnam
*Data from the World Bank World Development Indicators, 2000-2010. www.worldbank.org.



Employment in Agriculture (% of population)
50
40
30
20
10
0
0
10
20
30
40
50
60
Poverty Headcount Ratio ($1.25 per day)
(Each point represents data from one of the following countries):
Bangaldesh
Brazil
Chile
China
India
Indonesia
Kenya
Mexico
Senegal
Sri Lanka
Turkey
United States
Vietnam
*Data from the World Bank World Development Indicators, 2000-2010. www.worldbank.org.

What type of graphs are these? How do you think that the data were gathered and the graphs constructed?

Summarize the implications of these graphs in one or two sentences.

Which point on each graph do you think represents the United States? Which do you think represents Bangladesh? Explain your reasoning.

Describe how you think the decline in U.S. production costs, and its global impact, will affect food security in the developing world.

What questions would you have for the creators of the graphs? Are there any ways in which you think these representations of the data could be misleading? Explain.

As the graphs shown above illustrate, many of the world's poorest, hungriest households earn their living from the production and sale of agricultural products. The developing world's reliance on food for income, in addition to sustenance, means that low food prices as well as high food prices can have negative impacts on global food security. If low production costs in developed countries push producer prices too low, less-efficient farmers in the developing world will be unable to cover their own, higher costs. Lack of reliable income will prevent these households from purchasing efficiency-enhancing inputs and technology, and will thus perpetuate their slide toward lower productivity and deeper poverty.

Competition between large commercial farms in developed countries, and poor small farmers in the developing world, is not hypothetical—the cost and price effects described in this example are a very real food security problem. Imagine that you are the leader of a developing country whose citizens depend on agriculture for their livelihoods. How might you respond to this problem? Brainstorm as many ideas as you can, and record them in the space below or on a separate sheet. When you have listed all the strategies that you can think of on your own, read through the suggestions on the next page.

Both developed and developing country governments have implemented various measures to protect local producers from international price competition. These measures include:

- Direct price controls: If the domestic price of a commodity falls low enough—or rises high enough—to threaten farmers' livelihoods and/or general food security, government officials might choose to impose legal bounds on the price for which retailers can sell the commodity. An upper bound on price is called a price ceiling; a lower bound is called a price floor.
- Producer subsidies: These are direct payments to farmers to help them cover the costs of production. Farmers who receive government subsidies can afford to sell their crop for a lower price; the extra income from the subsidy allows them to purchase inputs and other necessities to stay in business, even if they lose income on the sale. Governments may also choose to offer subsidies or other incentives for retailers and wholesalers who purchase from domestic producers.
- Tariffs: A tariff is a tax imposed on imported goods. Tariffs raise the price of imported food and other nondomestic goods, making it easier for domestic producers to compete if they face higher production costs. For example, a tariff on U.S. maize could be used to raise the wholesale price of U.S. maize in a developing country. With a high enough tariff, retailers and consumers would face the same price for imported maize as for domestic maize, and would shift their purchases back toward domestic producers.
- Other trade restrictions: Some governments might prefer to control the total quantity of imports, rather than the import price. Such an import quantity restriction is known as an import quota. In extreme cases, a government might choose to ban imports of some products entirely.

price ceiling—one example of a direct price control, an upper limit (usually imposed by a government) on the price of a good or service

price floor—one example of a direct price control, a lower limit (usually imposed by a government) on the price of a good or service

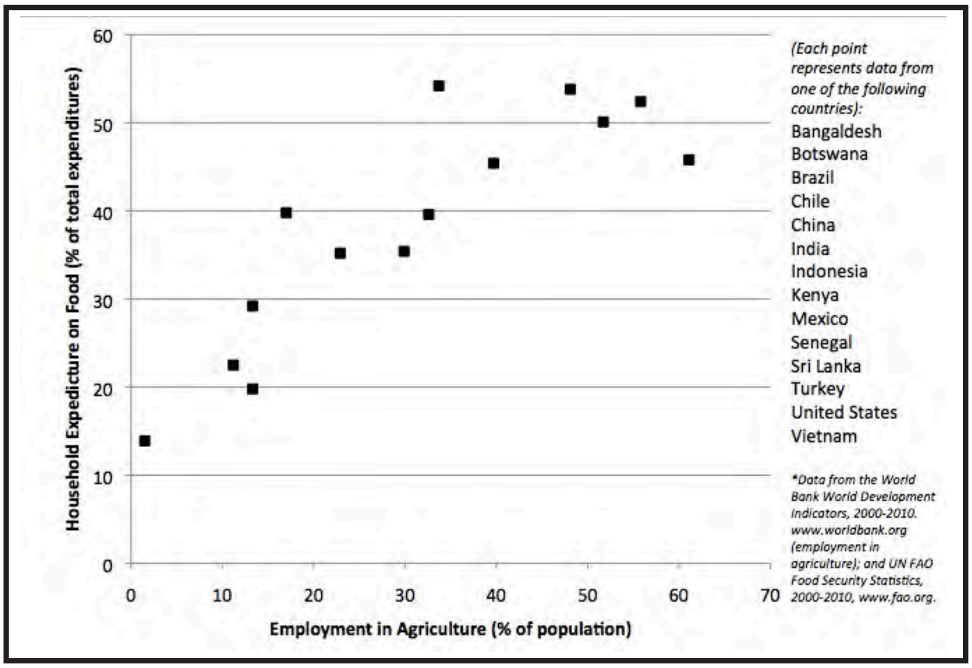
subsidy—a direct or indirect payment, usually granted by a government, intended to promote economic activities deemed to be beneficial to society

tariff—a tax levied on traded goods

import quota—a mandated maximum or minimum amount; for example, an import quota usually specifies the maximum quantity of a particular good that a country will import

Which of these strategies do you think would be the most effective in improving food security in a developing country? Why? What problems would you anticipate with the other strategies? What, if any, problems would you anticipate with the strategy you chose?

Refer to the graph below as you develop your answer. Include a one-sentence summary of the graph's implications in your response. Write in the space below, or use a separate sheet.



When considered alongside the data and graphs presented earlier in this section, the graph shown on the preceding page illustrates a fundamental food security dilemma: *Many of the poorest households in the world sell food to earn income, and are thus negatively affected by low food prices; however, many of those same households spend over half of their disposable income on food, and are thus negatively affected by high food prices*. Among food security scholars, this problem is known colloquially as the "food price dilemma."

Research suggests that the poorest rural households buy more food than they sell, and thus are more negatively affected by high food prices than by low food prices. For this reason, government attempts to support poor domestic farmers by raising food prices—whether through trade barriers or direct price controls—often backfire, sometimes on the very households that they had aimed to protect. Producer support payments can achieve greater success; however, these programs are costly to implement, and may fail due to government corruption or political manipulation by wealthy commercial farmers.

Most experts agree that, although food prices have played a role in many short and long-term food security crises, real progress toward global food security will not be attained through direct control of either producer or consumer prices. Successful measures will need to address the more fundamental problem underlying the food price dilemma—specifically, the strong association between poverty and agriculture in the developing world. Small farmers in developing countries will need to raise their productivity so that they can compete in global markets, diversify their income sources, and promote sustainable national economic development. Upcoming lessons in this unit explore programs and strategies that may help them achieve those goals.

Exercise: Food Price News Analysis

Search online for a news article on the topic of food prices. Your article should be one that appeared in a credible news outlet (i.e., not on a personal Web site or blog) during the past 5–10 years, and may discuss global, regional, or local food price trends. Read your article carefully, and fill in the information below. Print a copy of your article to turn in.

Article title:

Source:

Date:

Does the article mention any factors or trends that may be affecting food prices? If so, list those factors below, labeling each as a supply factor or a demand factor. Which factor or factors do you think are most important, i.e., have the greatest influence on prices in this scenario?

Does the article discuss food prices in general, or does it focus on a specific product/crop? If the latter, list the product/crop below. Do you think that prices for this product/crop are correlated with prices of other food products? Why or why not?

Does the article discuss global food price trends, or does it focus on a particular country/region? If the latter, list the country/region below. Are the price trends discussed in the article are confined to this country or region? How do you know, or how could you guess?

Does the article distinguish between producer, wholesale, and retail prices? Do you think the distinction is important in this scenario? Why or why not?

Does the article mention any food security effects of the food price trends discussed? If so, describe the effects below:

Did the article's author consider the effects on both the consumers and the producers of the food products mentioned? Do you think he or she overlooked any potential effects? Explain:

Does the author suggest any strategies for addressing food security effects? If so, describe them below, and explain why you would or would not expect these strategies to improve food security in both the short and long term.

Summarize the article's main conclusion in a single sentence:

What questions would you have for the author of the article or for any of the sources that he or she cites?

List any unfamiliar terms in the article. Consult an online source for brief definitions of these terms, and summarize each definition below:

Quiz

1. Describe how an increase in consumers' willingness to pay for tomatoes would affect the demand for tomatoes, the supply of tomatoes, and the price of tomatoes. Suggest at least one factor that might account for the increase in willingness to pay.

2. Explain how—and why—a dramatic increase in the cost of producing corn would affect the demand for wheat, the supply of wheat, and the price of wheat.

3. List two reasons that commodity prices may differ between countries. Explain each reason with an example, and indicate which country in your example would have the higher price.

4. The wholesale price of carrots in a certain market is $1 per pound.
   a. In what range would you expect the producer price to be (higher than $1, lower than $1, about $1)?

   b. In what range would you expect the retail price to be?

   c. Explain the logic behind your answers in (a) and (b).

5. Explain why the government of a developing agricultural country might choose to impose tariffs on agricultural commodities.

6. Describe the food price dilemma.

Lecture Summary, "Managing Food Price Volatility"

Experts debate path to "food security"
The Stanford Daily
Friday, May 27, 2011
By Tyler Brown

Peter Timmer, visiting professor at the Freeman Spogli Program on Food Security and the Environment, and Michigan State University professor Thom Jayne debated how to promote "food security" in developing countries on Thursday. The lecture was the fourth session in a series presented by the program that brings experts in food economics to speak at Stanford.

"What should we actually be doing in this crazy market for consumers, producers, especially for the bottom billion, those that are barely able to feed their families?" asked program director Rosamond Naylor.

Timmer suggested that smoothing out food prices might do the trick.

"There is a food price dilemma: farmers like prices high and consumers like prices low—there's always going to be some controversy," Timmer said.

"Something between too high and too low can be the right price," he added.

"A lot of us would like to be able to go there directly," Timmer said. "There's a real incentive to try to do that, and the problem is market economies don't work that way."

Long-term food security, he said, requires investments that are accessible to get out of poverty.

"My question today is: couldn't we think about this a little more systematically?" he asked.

On a macroeconomic scale, he suggested that governments prepare buffer stocks and set import and export controls to manage prices.

"One of the major factors in the long run in poverty reduction is making sure food is accessible to the poor…lower real prices are important," he said.

He noted that price instability is a problem both at the household level, where consumers have trouble adjusting their budgets, and for investors.

“When investors can’t clearly see the price signals…you can’t make good investments,” Timmer said. “And when the rate of investment falls, economic growth slows.”

Timmer concentrated primarily on the staple grains in his talk. Large food reserves, he said, are an instrument to stabilize prices. Throughout Asia, there are efforts to build village reserves.

“Social safety nets, to be honest—I don’t think they work for food crises,” Timmer said. “They have a terrible track record for coping with sudden crises.

“The real solution is clearly higher agricultural productivity,” he said.

A main problem is that it may take 20 to 30 years before investment leads to a visible global response. He added that slowing down the “financialization” of food commodities might help reduce price volatility for food.

But what’s the right price of food?

According to Timmer, the answer is $400 per metric ton for 25 percent broken rice—a conclusion that Jayne contested.

“I find myself in a very ironic position disagreeing with a lot of what [Timmer] said today,” Jayne said.

He agreed that food price instability is a major political and economic problem, but differed in many respects on the solutions.

“Price stability definitely seems to contribute to economic growth,” he said. “But price stabilization efforts don’t necessarily contribute to price stability. And government’s track record in stabilizing prices has been mixed at best.”

The two countries in Africa with the highest instability are the two that have governments most actively involved in price stabilization in the region, he added.

“A lot of things that are done in the interest of price stability just represent patronage and rent seeking,” he said.

Furthermore, high prices could have much more of a negative impact than instability per se.

“Over two thirds of the small farmers in Zambia don’t sell maize—they’re buyers,” Jayne said. “Poverty is rampant among the buyers. Now think about what will happen when the government comes along and pushes up prices ostensibly to help producers.”

Efforts to raise food prices tend to be regressive, he argued, and appropriate actions are to shift public budgets away from price stabilization and into investments that promote economic growth, such as macroeconomic management, crop science, basic education and health and infrastructure.

“These are the kinds of investments that we need to keep making,” he said.

Reading Guide: Lecture Summary, "Managing Food Price Volatility"

The questions below are intended to help you focus on key points from the *Stanford Daily* summary of Peter Timmer's lecture "Managing Food Price Volatility." The summary touches on many advanced topics, and you are not expected to understand all of the concepts or to provide a single "right" answer to each of the questions. Begin by consulting a dictionary or an online source for definitions of any unfamiliar terms or phrases. Then, as you work through the reading guide, think logically and creatively about how Timmer's ideas connect to the material you have studied in this lesson.

For more information on managing food price volatility, you may wish to consult the video of Peter Timmer's lecture and the accompanying academic paper, both available on the SPICE Web site. The following paper, available on the Stanford Center for Food Security and Environment Web site, provides additional insight into volatility issues:

Naylor, Rosamond and Walter Falcon. "Food Security in an Era of Economic Volatility." *Population and Development Review* 36(4): 693–723 (December 2010).

Unfamiliar terms:

Questions:

1. According to the article, Timmer believes that "there's a real incentive" to "go [to the right food price] directly." Explain what Timmer means by "go there directly." Give an example of a strategy that attempts to "go directly" to the "right" food price, and suggest a reason that this type of strategy might fail to improve price stability and food security in the developing world.

2. List three strategies that, according to the article, Timmer says could help to stabilize food prices:

3. Give an example of a "social safety net." According to the article, Timmer says that these safety nets have "a terrible track record for coping with sudden crises."Assuming his statement is true, why might this be the case?

4. Timmer says that instability in food prices creates problems not only for poor households but also for wealthier investors. What investments (e.g., major purchases, research grants, business ventures, etc.) might not occur if food prices seem likely to fluctuate? Why?

5. What does Timmer mean when he refers to the "financialization of food commodities"? Why might financialization increase price volatility?

6. According to the article, what reasons does Thom Jayne give for his skepticism regarding the benefits of price stability measures? What alternatives measures does he suggest to promote food security?

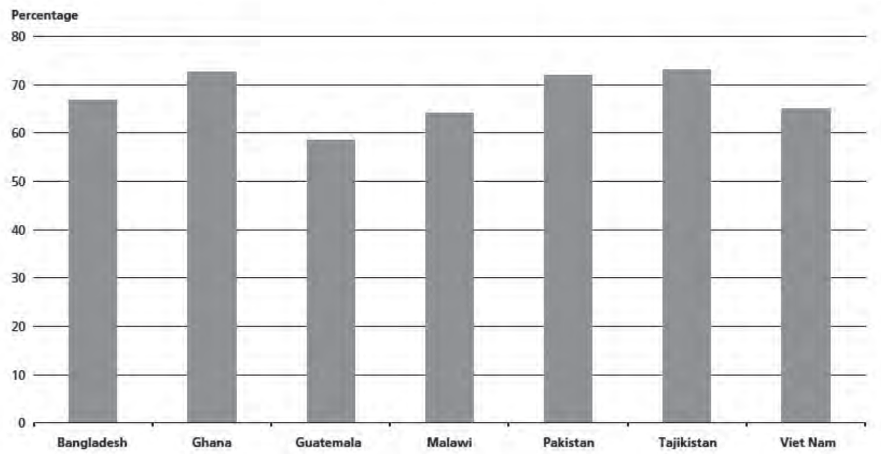
Household-level impacts of high food prices (FAO)

Excerpted with permission from "The State of Food Insecurity in the World: 2011." Food and Agriculture Organization of the United Nations. Rome: FAO, 2011.

Poor people spend a large majority of their income on food (Figure 4), while many farmers derive much of their income from producing food. This suggests that changes in food prices will have large effects on the welfare of both farmers and poorer consumers.

FIGURE 4

Poor people spend much of their income on food



Note: Percentage of household budget spent on food by the lowest expenditure quintile of the population.
Source of raw data: FAO Rural Income Generating Activities project.

In order to understand the importance of higher food prices for welfare, poverty and food security, it is important to distinguish between net food sellers and net food buyers. A net food seller is someone for whom the total value of the food they produce exceeds the total value of the food they consume, whereas for a net food buyer the reverse is true. Net food buyers will generally be hurt by higher food prices, while net food sellers will benefit.

net food seller—someone for whom the total value of the food they produce exceeds the total value of the food they consume

net food buyer—someone for whom the total value of the food they consume exceeds the total value of the food they produce

The concepts of net food seller and net food buyer are quite distinct from whether the household is rural or urban. Nearly all urban dwellers are net food buyers; perhaps surprisingly, most rural dwellers also are net food buyers. Very-small-scale farmers and agricultural laborers are often net purchasers of food as they do not produce enough food for their families. They thus need to purchase food from the market and are likely to benefit from lower prices. These landless or land poor rural households are often the poorest of the poor, and a disproportionately large proportion of such households are headed by women.

In urban areas, higher food prices may substantially hurt the poor

disposable income—income available to be spent or saved at the discretion of its earner (after deduction of taxes, mandatory charges, etc)

asset (productive asset)—a physical item, or a characteristic of a person or group, that has monetary value or income-generating potential

micronutrients—nutrients that the body requires in smaller daily quantities (as opposed to macronutrients—carbohydrates, protein, and fat—which are required in large quantities). Micronutrients include vitamins, such as vitamins A, C, D, and K, and minerals such as calcium and iron

because, typically, little food is produced in such areas and because food typically accounts for a large share of expenditures for the poor. In order to cope with the reduction in disposable income resulting from higher food prices, households will engage in new economic activities, sell assets or borrow in order to mitigate the decline in consumption. They also commonly reduce expenditures on health and education and shift dietary patterns towards cheaper (starchy) foods and away from micronutrient-rich foods such as milk, meat, and fruits and vegetables. Energy intake will also decline in cases where people are so poor that they simply cannot afford the same amount of calories at the new higher prices.

In rural areas, higher food prices will tend to have smaller negative effects on net food buyers because many households produce a substantial share of what they consume, and hence are only marginal food buyers. On the other hand, farmers who are net food sellers are likely to benefit from higher prices, which, other things being equal, will tend to increase their income. Since many farmers are poor, higher prices could help to alleviate poverty and improve food security.

However, it must also be kept in mind that farmers with more surplus production to sell will benefit more from high prices than farmers who have only a small surplus to sell. Further, in most (but not all) contexts, farmers with more land tend to be better off than farmers with only a little land, so it may be that poorer farmers will not receive the bulk of the benefits from higher food prices. Overall beneficial impacts of higher food prices on poverty are more likely in countries with a relatively equal distribution of land.

Another potentially important effect of food prices on poverty and food security operates through labor markets and wages. Higher food prices stimulate demand for unskilled labor to work on farms, which might result in an increase in rural wages in the long run. This would benefit households that are dependent on wage labor for their income (who are usually very poor). The evidence in this regard is inconclusive, however, and depends on the importance of agriculture in the overall economy and how many years the adjustments in wages take. The labor market channel is worthy of more study, as there is scant information available concerning its effects on poverty and food security.

Given these considerations, what does the evidence show about the impact of high prices on poverty? The average income of net food buyers is higher than that of net food sellers in most developing countries, and thus high food prices would transfer income from higher-income people to those with lower income. But this conclusion results from dividing the population into just two groups; studies that use a more detailed disaggregation nearly always show that the poorest 20 percent of the population are net food buyers, with surplus-producing farmers somewhere in the middle of the income distribution.

For example, higher food prices increased poverty in seven of nine countries studied, with Peru and Vietnam being the only exceptions.

Vietnam is a substantial rice exporter with relatively equitable land distribution; as a result it has many households that produce a surplus of rice but that are still relatively poor. In Peru, the beneficial impact was very small. In all other countries in the sample (Bolivia, Cambodia, Madagascar, Malawi, Nicaragua, Pakistan and Zambia), higher prices increased poverty, even after taking account of increased labor demand.

Another study reached similar conclusions—the poor were hurt by higher prices in all countries studied (Albania, Bangladesh, Ghana, Guatemala, Malawi, Nepal, Nicaragua, Pakistan, Panama, Tajikistan and Vietnam), with the exception of rural dwellers in Vietnam. This study did not examine labor market effects, but did incorporate supply and demand responses, and found that high prices still hurt the poor. Higher prices also increased poverty in Guatemala, Honduras, Nicaragua and Peru. A review of a large number of studies pertaining to rice (including Indonesia, the Philippines and Thailand) found that the poorest quintile of the population is nearly always a net purchaser of rice. Taken together, these studies show that the poorest 20 percent of the population are net food sellers only in unusual circumstances.

quintile—twenty percent (one-fifth)

Different types of studies provide further support for the idea that high food prices hurt the poor, and in more ways than just pushing them below the poverty line. Generally speaking, energy intake is less affected than dietary diversity and consumption of protein and micronutrients. As one example, when rice prices increased in Indonesia during the Asian financial crisis in the late 1990s, households reduced purchases of more nutritious foods such as eggs and green leafy vegetables in order to continue to buy rice. This led to a measurable decline in blood hemoglobin levels in young children (and in their mothers), thus increasing the probability of developmental damage. In addition, mothers in poor families responded by reducing their caloric intake in order to feed their children better, leading to an increase in maternal wasting. A negative correlation between rice prices and nutritional status has also been observed in Bangladesh. Height for age scores among children under three years old in El Salvador declined during the 2006–08 food crisis, although the effects were mitigated to some extent for families with access to remittances from family members overseas. Weight for age did not decrease, suggesting that there was a decrease in consumption of key nutrients but not in energy intake. In some situations, though, even energy intake may decline, in addition to dietary diversity.

wasting—low weight for age; a symptom of undernourishment

Furthermore, high food prices seem to have a disproportionate negative impact on female-headed households, for two reasons. First, these households tend to have less access to land and other resources, often because of customary laws and social discrimination; as a result, they are less likely to be net sellers of food. Second, these households also tend to be poorer, which means they spend a larger share of their income on food and are more affected by high prices.

In addition to affecting different types of households differently, changes in food prices also affect different household members differently.

For example, women's participation in the labor force may increase substantially during economic crises, such as when males migrate in search of better employment. The resultant additional workload places stress on the time they have available to engage in household work and childcare. The mortality of infant girls also increases more than that of infant boys during crises.

Key message

In the short term, the benefits of high prices go primarily to farmers with a large marketed surplus, and these farmers are not the poorest of the poor. In addition, the poorest people usually buy more food than they sell. Thus, high food prices tend to worsen poverty, food insecurity and malnutrition. However, high prices represent an opportunity to spur long-term investment in agriculture, which will contribute to sustainable food security in the longer run.

subsidy—direct or indirect payment, usually granted by a government, intended to promote economic activities deemed to be beneficial to society

While high food prices harm the poor in most cases, this is not an argument for generalized price subsidies. Such subsidies are often politically difficult to remove and can drain government budgets of the funds needed for investment in public goods such as agricultural research, rural roads, education, health and sanitation. Generalized price subsidies are also generally regressive, in the sense that most of the benefits are captured by the well-to-do, who, despite spending a smaller proportion of their budget on food than do the poor, spend more money on food in total than do the poor.

But if general subsidies are not the answer, what is the best way to help mitigate the adverse effects of high food prices? In the short term, one option is to target food safety nets to the most vulnerable. Over the longer term, the best way to lower food prices is to invest in agriculture; this will sustainably increase yields, reduce input costs, increase productivity and reduce food losses and waste. These investments have the potential to make food more affordable for consumers and more profitable for farmers, and are the only way to manage food prices in a way that benefits everyone. In this sense, the cure for high prices may be high prices, provided that the high prices motivate farmers to adopt improved technologies and national governments and international donors to increase the financial resources available for investment in agriculture. Thus, while high prices make the problem of food insecurity and poverty worse in the short run, they also represent an opportunity for investment and growth that can reduce food insecurity and poverty in the long run.

Reading Guide: "Household level impacts of high food prices"

This reading is excerpted from the 2011 edition of an annual U.N. Food and Agricultural Organization report entitled "The State of Food Insecurity in the World." In response to food price spikes in that year, the 2011 report focuses on the food security effects of food price fluctuations. This excerpt explains many of the same concepts that you have learned in Part One of Lesson Three, using slightly more advanced vocabulary and citing evidence from research and case studies conducted in developing countries.

Read the excerpt carefully. Note any unfamiliar terms or phrases, consult a dictionary or online source for their definitions, and record your findings in the space below before answering the questions that follow. As you complete the reading guide, think about how the report's conclusions relate to and extend the topics that you have covered in this lesson. Use your new economic vocabulary and the examples and analogies given in the report to restate important conclusions in familiar terms.

Unfamiliar terms:

Questions:

According to the FAO report, changes in food prices will have large effects on both ____________ and ______________, because ____ ________.

Do poor rural households tend to be net food buyers or net food sellers? Explain.

Name three countries in which poor households spend more than 70 percent of their income on food:

The report lists several ways that poor households might cope with an increase in food prices. In your own words, describe at least three possible coping strategies.

Who benefits most from higher food prices? Why is this distribution of benefit problematic from a food security perspective?

How might higher food prices affect rural wages? Why?

According to the report, "The average income of net food ____________ is higher than that of net food ____________ in most developing countries ... But ... the poorest 20 percent of the population are net food _____________." Explain how this statement might inform food price and food security policies.

Several studies have shown that in most countries, higher food prices hurt the poor. One frequent exception in these studies is Vietnam. According to the article, why do higher food prices benefit poor rural Vietnamese households, despite their proven negative effects elsewhere?

According to the report, when food prices increase, "energy intake is less affected than dietary diversity and consumption of protein and micronutrients" among the poorest households. Explain this statement in your own words (one or two sentences):

How do the effects of high food prices on women differently from those on men? Why?

Explain what the report's authors mean by "generalized price subsidies." What arguments does the report make against such subsidies?

What alternative strategies does the report suggest to improve food security, particularly in the long term?

TRADE CONTROLS BUFFER DOMESTIC PRICES

Excerpted from "The State of Food Insecurity in the World: 2011." U.N. Food and Agriculture Organization. Rome: FAO, 2011.

The two graphs below show fluctuations in rice and soy prices in China between 2005 and 2008. Study the graphs carefully, and then respond to the following questions:

- Why do you think that the Chinese government controls trade in rice but not trade in soybeans?

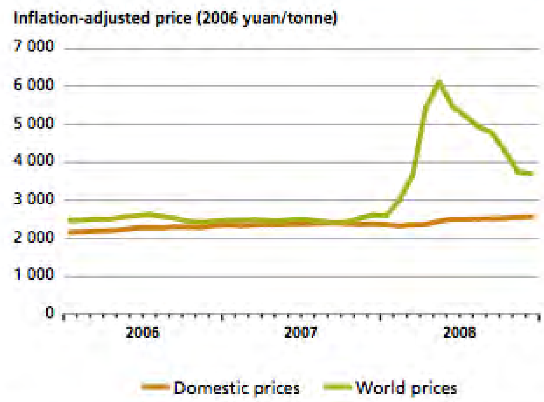
- What type of trade control would you guess that the Chinese government imposes on rice (import barrier or export barrier; tariff or quota)?

- Compare the spike in world rice prices with the spike in world soybean prices. Which spike is larger? Which is steeper? How might you explain the differences?

- While Chinese soybean prices parallel world prices, they are consistently slightly higher. Why do you think this is the case?

FIGURE 7

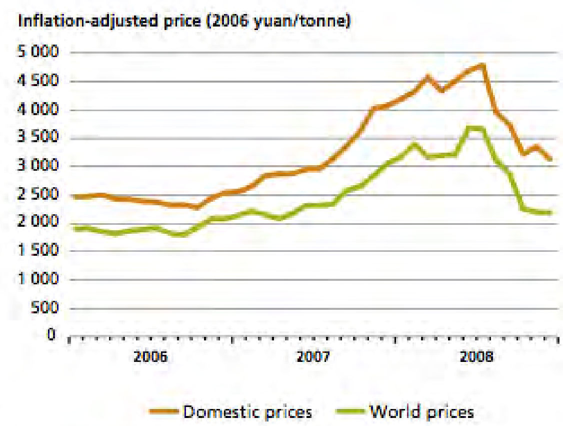
Government control of trade in rice prevented high world market prices from affecting domestic prices in China during the 2006–08 food crisis



Source: C. Fang. 2010. How China stabilized grain prices during the global price crisis. *In* D. Dawe, ed. *The rice crisis: markets, policies and food security*. London, Earthscan and Rome, FAO.

FIGURE 8

The Chinese government does not control trade in soybean, and domestic prices follow world market prices



Source: C. Fang. 2010. How China stabilized grain prices during the global price crisis. *In* D. Dawe, ed. *The rice crisis: markets, policies and food security*. London, Earthscan and Rome, FAO.

Writing Exercise

1. In a short essay (two or three well-organized paragraphs, no more than 500 words), respond to the following question: As a poor farmer in the developing world, would you prefer to face local food prices that are "too high" or "too low"? Consider the following issues:
   - How would a developing-country farmer define "too high" and "too low" in the context of food prices? In other words, how would you know when prices have risen too much or fallen too far?
   - Which alternative (high prices/low prices) poses a greater threat to a farm family's short-term health and livelihood? Reflect on what you know about household expenditures in developing countries.
   - Which alternative is more problematic from a long-term poverty reduction standpoint—i.e., which presents a greater obstacle to a farmers' ultimate escape from poverty?
   - Does one alternative (high prices or low prices) seem easier to address through policy action (trade barriers, subsidies, etc.)? If so, why?
   - As a farmer, what options would you have to improve your situation if prices are "too low"? What if prices are "too high"? In general, how much control would you have in each situation?

2. Refer to the supplementary handout "Trade Controls Buffer Domestic Prices." In a short essay (two to three well-organized paragraphs, no more than 500 words) answer one of the following questions:
   a. Should China have imposed soybean trade barriers in 2008, to prevent domestic prices from following the world price spike? Why or why not?
   b. Should China remove rice trade barriers now that world rice prices have stabilized after the 2008 spike? Why or why not?

   Consider the following as you compose your response:
   - How important is rice/soy as a food calorie source for poor households in China?
   - How important is rice/soy farming as a source of income for poor households in China?
   - Who would benefit from trade controls, and who would be hurt? Think about how trade controls would affect wealthier vs. poorer households.
   - What might be the domestic and international political implications of trade controls?
   - Would long-term effects of trade controls differ from short-term effects? Why?

You may draw on any of the materials in this unit in answering these questions; you will probably also wish to consult a few additional resources. The United Nations Food and Agriculture Organization home page (www.fao.org) is a good place to begin any research on food prices and food security issues, and the United States Department of Agriculture (www.usda.gov) is another useful source. Whatever sources you use in your response (beyond the materials in this unit), be sure to cite them properly.

Answer Key to Handout 1
(Viewing Guide, Gregory Page and Jeff Raikes Video Clip)

1. Undernourishment is most prevalent in ________________ , where ______ percent of children are chronically malnourished.
   Sub-Saharan Africa; 38 percent

2. Undernourishment in this region mentioned above is primarily an issue of inadequate __________________________.
   Food production—note that, as seen in Lesson Two, sub-Saharan Africa has some of the lowest crop yield and production numbers in the world.

3. The two countries with the highest numbers of malnourished people are _________ and __________.
   India and China

4. Why is the answer to (3) surprising? To what factors does Greg Page attribute the extent of malnourishment in these two countries?
   India exports both corn and soybeans, while the Chinese government has substantial cash reserves—sufficient to import and distribute enough food to provide for its hungry citizens. Page says that malnourishment in these two countries as an issue of "willingness and commitment" to feed people. For discussion: What specific factors could contribute to poverty and malnourishment in a country with an overall surplus of food and/or money? (Good answers include inequity, i.e., a few people control the majority of physical and economic resources; inefficiency or corruption in government agriculture and food aid programs; a substantial share of agricultural production going to export or for use as livestock feed; etc.)

5. According to the UN Food and Agriculture databases—and Cargill's calculations—"extinguishing hunger" would require _____________ tons of whole grain, about one-sixth the amount we currently use for ________________.
   Thirty million tons; about one-sixth the amount we currently use for fuel
   For discussion:
   - *What grain crop is used in the United States and other industrialized countries to produce what common fuel? (Corn/ethanol)*
   - *Do you see any problems with Page's calculation? (Possible answer: Humans need a diverse, protein-rich diet and cannot live exclusively on grains).*

6. Page suggests that our failure to extinguish hunger is an issue not of ____________ famine but of _________________________.
   Not of caloric famine but of economic famine. Page rephrases this by saying that global hunger is "not a food supply problem, but an issue of having the purchasing power to pay for a diet."

   For discussion: Rephrase Page's statement in your own words. (Good answer: The problem isn't that *we don't have enough food to go around, but rather that some people can't afford to buy food.)*

7. According to Page, the "fundamental ingredient of sustainable agriculture" is ________________________.

   Adequate price to reward the farmer and to enable him or her to plant and harvest again in the following year.

   For discussion: Why might small farmers in the developing world, in particular, face sale prices for their output that they find to be too low to sustain their livelihoods?
   Good answers may focus on any of the following themes:
   - *Small farmers in developing countries must compete in a global market with large industrial farms in developed countries; these large farms realize economies of scale (i.e., they can produce much more output with only modestly greater investment in machinery, land, irrigation equipment, etc.) that enable them to sell their output at very low prices and yet remain in business.*
   - *Developing-country farmers have to contend with infrastructure problems—poor roads, lack of refrigeration, etc.—that make marketing and distribution more difficult and costly than in developed countries.*
   - *Consumers in developing countries may be very poor—if small farmers are selling their output locally, they may have to sell at a very low price to retain customers.*

Answer Key to Handout 7 (Food Price Dynamics Point #5)

Malnutrition/Poverty Graphs

What type of graphs are these? How do you think that the data was gathered and the graphs constructed?

These are scatterplots. Each point plots one country's share of employment in agriculture on the x-axis against malnutrition/food expenditure share on the y-axis. The data most likely come from government censuses or on-the-ground household surveys by researchers.

Summarize the implications of these graphs in one or two sentences.

Countries in which most of the population works in agriculture are, in general, more likely to have high overall child malnutrition and poverty rates.

Which point on each graph do you think represents the United States? Which do you think represents Bangladesh? Explain your reasoning.

Malnutrition graph: The United States is the point in the lower-left corner of the graph (1.5, 1.3); Bangladesh is the second-highest point (48.1, 41.3).

Food expenditure graph: The United States is the leftmost point (1.5, 13.9); Bangladesh is the fourth point from the right (48.1, 53.8).

We expect the United States to have a low malnutrition rate and low household food expenditure share compared with the other countries on the list (mostly developing countries). It is interesting to note that the U.S. share of employment in agriculture is also one of the lowest in the world—recall from Lesson One that the U.S. is a top producer of many major agricultural staples. This juxtaposition of high production and low employment share reflects the fact that agriculture in the United States is a highly mechanized industry, while agriculture in the developing world still relies heavily on human labor. In the United States, in short, machines have replaced people, resulting in cheaper, more efficient food production.

Describe how you think the decline in United States production costs, and its global effects, will affect food security in the developing world.

Answers will vary. Students should recognize that low food prices will hurt poor households that rely on agriculture for income, and that, according to the data presented here, poverty and employment in agriculture are strongly positively correlated.

What questions would you have for the creators of the graphs? Are there any ways in which you think these representations of the data could be misleading? Explain.

Answers will vary—the goal of this question is to provoke students to view the data and representation with a critical eye. Some possible questions and issues might include:

- *How were the data collected? Are the numbers in the graph based on representative samples of the countries' populations?*

- *How is employment in agriculture measured? Does the value include only people directly engaged in growing food, or does it include those who work in related industries, such as agricultural research or agricultural equipment manufacturing?*
- *Similarly, how is food expenditure share measured? Does "food" include all consumables, or does it omit "luxury" products such as coffee, alcohol, etc.?*
- *Finally, how is "underweight" defined in the context of malnutrition? Is the weight cutoff the same across all countries, or does it vary—perhaps based on overall averages in the country's population, for example?*
- *How were the countries in the graph selected? Would the trend look different with different country samples?*
- *How do population sizes compare across these countries? Would the trend look different if the data were presented in raw numbers rather than in percentages?*

Food Expenditure Share Graph

Graph implications: In countries in which a high proportion of households rely on agriculture for income, households also spend a large share of that income on purchased food.

This observation underscores the crux of the food price dilemma, i.e., many households sell food for income while at the same time purchasing food for their own consumption. An increase in food prices helps these households as sellers but hurts them as consumers. If the members of a household buy more food than they sell—as the members of many small farm households in the developing world do—a rise in food prices has a negative net effect on the household's immediate food security situation; but in the long term, the price increase may help the household members increase their income and invest in land, education, or other assets that could lift them out of poverty. If food prices remain very low, the households' long-term prospects are much bleaker.

Note: A household's food expenditure share reflects the amount of flexibility that the household has in responding to an increase in food prices or a decrease in income. Households with higher food expenditure shares have less flexibility. For example, a richer household might put off purchases of clothes, books, or equipment in order to afford food; but a poor household, in which most money already goes to food and "luxury" purchases are few, cannot make similar substitutions.

Answer Key to Handout 9 (Quiz)

1. Describe how an increase in consumers' willingness to pay for tomatoes would affect the demand for tomatoes, the supply of tomatoes, and the price of tomatoes. Suggest at least one factor that might account for the increase in willingness to pay.
   The increase in willingness to pay will cause demand for tomatoes to increase, supply relative to demand to decrease (in the short term), and price to rise. Factors that might account for the increase in willingness to pay include (but are not limited to) news articles touting the health benefits of tomatoes, a rise in the price of products often substituted for tomatoes, a drop in the price of products frequently consumed with tomatoes, etc. See Handout 3, Food Price Dynamics Point #1, *for a complete explanation.*

2. Explain how—and why—a dramatic increase in the cost of producing corn would affect the demand for wheat, the supply of wheat, and the price of wheat.
   The increase in the cost of producing corn would be passed on to consumers in the form of an increase in the price of corn. Consumers would seek to substitute less-expensive products, e.g., wheat, causing demand for wheat to rise. Supply of wheat relative to demand would thus fall (in the short term), and the price of wheat would rise. See Handout 4, Food Price Dynamics Point #2, *for a complete explanation.*

3. List two reasons that commodity prices may differ between countries. Explain each reason with an example, and indicate which country in your example would have the higher price.
   Student answers will vary. See Handout 5, Food Price Dynamics Point #3, *for a selection of possible answers and explanations. Creative students may also give answers not listed in this handout; award points for logical answers that include examples and thorough explanations.*

4. The wholesale price of carrots in a certain market is $1 per pound.
   a. In what range would you expect the producer price to be (higher than $1, lower than $1, about $1)?

   Lower than $1

   b. In what range would you expect the retail price to be?

   Higher than $1

   c. Explain the logic behind your answers in (a) and (b).

   The wholesale price will be marked up from the producer price to cover the wholesalers' costs and profits, and the retail price will be marked up from the producer price to cover the retailers' costs and profits. See Handout 6, Food Price Dynamics Point #4, *for a complete explanation.*

5. Explain why the government of a developing agricultural country might choose to impose tariffs on agricultural commodities.
   The government would most likely be seeking to protect domestic producers from price competition with foreign producers, who may face lower production costs. See Handout 7, Food Price Dynamics Point #5, *for a complete explanation.*

6. Describe the food price dilemma.
   In poor countries, many households spend a large share of their income on food and yet simultaneously rely on the sale of food products for their income. These households are thus hurt by both increases and decreases in food prices. See Handout 7, Food Price Dynamics Point #5, *for a complete explanation.*

Answer Key to Handout 11 (Reading Guide: Lecture Summary, "Managing Food Price Volatility")

Note: The lecture summary touches on many advanced concepts, and students are not necessarily expected to capture all of the points below in their responses. Instructors should use this key as a guide for discussion, focusing on those questions and concepts that are of most interest to students. In evaluating student work, award points for thoughtful, thorough, and logical answers that draw on the ideas presented in this lesson.

For more information on these topics, instructors and students are encouraged to consult the video of Peter Timmer's lecture and the full version of his paper (citation below) on the subject of food price volatility. Both of these resources are available on the SPICE Web site. The following paper, available on the Stanford Center for Food Security and Environment Web site, provides additional insight into volatility issues:

Naylor, Rosamond and Walter Falcon. "Food Security in an Era of Economic Volatility." *Population and Development Review* 36(4): 693–723 (December 2010).

1. According to the article, Timmer believes that "there's a real incentive" to "go [to the right food price] directly." Explain what Timmer means by "go there directly." Give an example of a strategy that attempts to "go directly" to the "right" food price, and suggest a reason that this type of strategy might fail to improve price stability and food security in the developing world.
   Timmer is referring to government-enforced price controls that manipulate food prices directly. For example, if milk is unaffordable for a majority of poor households, a government might set a maximum price for which milk can be sold. However, this strategy merely transfers the price burden to poor dairy farmers, who suffer an income loss as a result of the price control. In the long run, many dairy farmers may leave the business, resulting in a shortage of milk, which will have additional negative food security consequences.

2. List three strategies that, according to the article, Timmer says could help to stabilize food prices:
   Timmer mentions buffer stocks (food reserves held by a government or community to help stabilize prices and consumption when shortages occur), import and export controls to buffer the effect of global price swings in domestic markets, and investments in increasing agricultural productivity to reduce food production costs and increase global food supplies.

3. Give an example of a "social safety net." According to the article, Timmer says that these safety nets have "a terrible track record for coping with sudden crises." Assuming his statement is true, why might this be the case?
   Food and income assistance programs—from food stamps to emergency international food aid—all fall into the category of social safety nets. Timmer's main point here is that these programs simply react too slowly in the face of a sudden food price or food supply crisis. Timmer addresses the issue in greater depth in a paper that accompanied this talk:

   > *"The problem is that safety nets that reach the poor quickly and effectively take considerable time to design and implement, and are quite costly in fiscal terms if the poor are a substantial share of the total population. Historically, unless the country is already running a cash transfer program*

to the poor, the emergence of a food price crisis is too sudden for an effective government response." (Timmer 2)

In the best cases, even well intentioned governments may design safety nets that are slow and costly—in the worst cases corrupt officials may prevent program resources from reaching the poor at all. Additionally, from a long-term perspective, reactive safety net programs usually do not address root problems of poverty and low productivity—and thus fail to reduce vulnerability to future price fluctuations.

4. Timmer says that instability in food prices creates problems not only for poor households, but also for wealthier investors. What investments (e.g., major purchases, research grants, business ventures, etc.) might not occur if food prices seem likely to fluctuate? Why?
   The basic logic underlying Timmer's argument is as follows:
   If food prices are unpredictable, investments in agricultural productivity are likely to decline at all levels.
   - *Small farmers are unlikely to invest in better equipment, seed, irrigation systems, etc., if they are not confident that they can make up the cost of those investments when they sell their crops.*
   - *National governments and NGOs are unlikely to invest in infrastructure and research to increase agricultural productivity if they are not confident that those investments will pay off in increased national income and poverty reduction.*
   - *Private corporations are unlikely to invest in agriculture (e.g., to put money into research, infrastructure development, farm operations, distribution, etc.) in the developing world if they are not assured of a profit from those investments.*
   - *Lack of investment in agriculture stalls advances in agricultural productivity, contributing to uncertainty in food supply and ultimately to greater price instability.*

5. What does Timmer mean when he refers to the "financialization of food commodities"?
   Timmer is referring to the trade in food commodity "futures" contracts—agreements between a buyer and a seller to exchange a commodity at some point in the future for a price fixed in the present. For example, a buyer might agree in January to pay $6 per bushel for corn to be delivered in September. The seller must then sell at exactly $6 per bushel in September, even if the price of corn on the open market has risen or fallen dramatically in the intervening nine months.
   Trade in futures contracts can amplify the effects of small food price fluctuations, or even cause fluctuations that would not otherwise occur. For example, if buyers believe that the price of corn is going to rise rapidly over the next few months, they will try to "lock in" large futures contracts at the current price, essentially buying up the market supply of corn months before harvest. This speculation of high prices then becomes a self-fulfilling prophecy, as the shortage in the market drives prices higher.
   In some cases, the buyers of futures contracts are not actually interested in purchasing the commodity at all. As with financial stocks, futures traders will attempt to make a profit by "buying low and selling high"—buying many contracts when prices are low, and selling them to other traders when prices are high. This profit-driven trading can lead to sudden price swings that have much to do with the activity and speculation of traders, and little to do with actual supply and demand in the commodity market.
   In his paper, Timmer has this to say about the dangers of financial speculation:
   "…the 'financialization of food commodities' is a trend that is very worrisome. Huge volumes of financial liquidity looking for the next best speculative return have turned to commodities, including

basic food commodities, as a venue for diversifying financial portfolios, and increasing returns to investors. The world has never lived with the reality of pricing of food commodities as a direct function of financial speculation, rather than the reality of movements in basic fundamentals of supply and demand. The two are not disconnected, of course, but the volatility of financial investments, especially by hedge funds, large banks on behalf of rich clients, and even amateur speculators able to play as day traders, vastly overwhelms the reality of real movements in the supply of and demand for basic food commodities on a short-run basis." (Timmer 17)

6. According to the article, what reasons does Thom Jayne give for his skepticism regarding the benefits of price stability measures? What alternatives measures does he suggest to promote food security?
   Jayne gives two major reasons for skepticism:
   - *While price stability measures are productive in theory, developing-country governments have failed to implement those measures fairly or effectively in practice.*
   - *High prices, even if stable, have a negative net impact on food security because most small farmers in the developing world are net buyers of food (not net sellers).*

   As an alternative to implementing price stability measures, he suggests that developing country governments focus on promoting general economic growth through agricultural research, education, health programs, and infrastructure development.

Works cited: Timmer, Peter. "Managing Price Volatility: Approaches at the global, national, and household levels." Stanford Center on Food Security and the Environment: Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century. 26 May 2011.

Answer Key to Handout 13 (Reading Guide: "Household level impacts of high food prices.")

According to the FAO brief, changes in food prices will have large effects on both ____________ and _______________, because ____.

Farmers and poorer consumers, because the poor spend a large share of their income on food while farmers derive a large share of their income from selling food.

Do poor rural households tend to be net food buyers or net food sellers? Explain.

Poor rural households tend to be net food buyers. The poorest rural households are usually very small-scale farmers, meaning that they own little land and few productive assets such as agricultural machinery and irrigation systems. Thus, they do not produce enough food to feed their families, much less any surplus that they could sell. They must supplement their insufficient production by purchasing food from the market.

Name three countries in which poor households spend more than 70 percent of their income on food: *Ghana, Pakistan, and Tajikistan (see graph, Figure 4)*

The brief lists several ways that poor households might cope with an increase in food prices. In your own words, describe at least three possible coping strategies.

The brief lists the following possibilities:

Engage in new economic activities, e.g., get another job.

Sell assets, such as a home, car, or other valuable possession.

Borrow money or assets from friends, relatives, or lending institutions.

Reduce expenditures on health and education, and spend less money on nonessentials.

Shift dietary patterns toward cheaper foods, e.g., buy fewer fruits, vegetables, and meat and dairy products, replacing them with basic staple grains.

Who benefits most from higher food prices? Why is this distribution of benefit problematic from a food security perspective?

Farmers who produce the most surplus food benefit most from high food prices—simply put, they are selling more at the higher price, increasing their net income more than a farmer who sells only a little. The farmers who produce the greatest surplus tend to be richer farmers who own the most land and assets. Thus, even if a poor household is a net food seller, its members will gain only a small benefit from high food prices compared with the benefit gained by members of a richer household. High food prices are "regressive," in that they benefit the rich more than they benefit the poor.

How might higher food prices affect rural wages? Why?

High food prices provide an incentive for large, wealthier farmers to increase their production. The *increase in production increases demand for rural labor—farmers need to hire additional workers to plant and harvest a larger crop—and the increase in demand increases the price of labor (recall Handout 3,* Food Price Dynamics Point #1*). Because rural laborers are often the poorest of the poor—those who own no land of their own—the wage increase could be beneficial from a food security perspective.*

According to the brief, "The average income of net food ___________ is higher than that of net food ___________ in most developing countries ... But ... the poorest 20 percent of the population are net food ____________." Explain how this statement might inform food price and food security policies.

Buyers, sellers, buyers—this statement tells us that the very rich and the very poor are net food buyers (recognize that if the poorest 20 percent are net food buyers, but the average income of a food buyer is much higher than that of a food seller, the income of food buyers not among the poorest 20 percent must be quite high) and that, therefore, net food sellers tend to be those with neither very low nor very high incomes. If our goal is to improve food security among the poorest of the poor, we might be interested in lowering food prices; however, lower food prices also benefit the richest households and do not benefit the middle class. If our goal is to improve food security among the middle class, we would like to keep food prices higher.

As the brief suggests, we can think of the changes in food prices as "income transfers"—higher prices transfer income from buyers to sellers, i.e., from the rich and poor to the middle class, while lower prices transfer income from the middle class to the very rich and the very poor.

Several studies have shown that in most countries, higher food prices hurt the poor. One frequent exception in these studies is Vietnam. According to the article, why do higher food prices benefit poor rural Vietnamese households, despite their proven negative effects elsewhere?

Vietnam has an unusually equitable land distribution—even the poorest households own a moderate amount of land and can produce enough food (mostly rice) to sell a surplus. Thus, even the poorest households can benefit from higher food prices.

According to the brief, when food prices increase, "energy intake is less affected than dietary diversity and consumption of protein and micronutrients" among the poorest households. Rephrase this statement in your own words (one or two sentences):

When food prices increase, the poorest households don't necessarily consume fewer calories, but the foods that they eat are less varied and less nutritious. For example, a household might go from consuming around 2,000 calories per day in meat and vegetables to consuming the same 2,000 calories in rice and beans.

How do the effects of high food prices on women differ from those on men? Why?

Women tend to be more negatively affected by high food prices. Cultural traditions often make it difficult for women in developing countries to own land. Thus, households headed by women are much less likely to be net sellers of food. Women also tend to be poorer and to spend a higher share of their income on food. High prices in a poor economy may push more women into the labor force—perhaps increasing their household income, but also increasing their daily calorie requirements and reducing the time they have *available to care for children.*

Explain what the brief's authors mean by "generalized price subsidies." What arguments does the brief make against such subsidies?

The brief is referring to producer or consumer subsidies intended to lower the net price of food—either direct payments to farmers, increasing their income so that they can afford to sell food for a lower price, or food aid payments to poor consumers. The brief argues that these subsidies may be "politically difficult to remove," i.e., the government may be forced by either producers or consumers to leave them in place long after they are necessary, and that subsidies "drain government budgets" of funds that could be spend on improving infrastructure and government services. Additionally, because wealthier consumers tend to spend more total money on food than poorer consumers do, the distribution of benefits from these subsidies is skewed toward the rich.

What alternative strategies does the brief suggest to improve food security, particularly in the long term?

The brief's authors argue that the best way to improve food security is to invest in increasing agricultural productivity—to make food production less costly, so that surplus-producing farmers can sell for a lower price and still make a profit. According to the brief, high prices could help to achieve such increases in agricultural productivity, as they make food production a more profitable and attractive enterprise, providing an incentive for wealthier farmers, corporations, governments, and scientists to develop and implement new methods to produce more food.

Lesson Four

Economic Access to Food
Part Two: Poverty

Organizing Questions

- How do features of poverty differ between developing and developed countries?
- What is a productive asset, and how are productive assets linked to poverty?
- What are the key features of a poverty cycle or "poverty trap"?
- What strategies have the greatest potential to alleviate poverty in the rural developing world?

Introduction

Part Two of Lesson Four focuses on poverty: its characteristics, causes, and potential antidotes in the rural developing world. Students begin by exploring how features of poverty, such as duration and depth, differ between developed and developing countries. Armed with new definitions that accurately describe these differences, students move on to investigate causes of ultra-poverty and chronic poverty, focusing on the role of productive assets in a rural poverty cycle. The lesson concludes with a group project that invites students to develop their own anti-poverty strategies. Throughout the lesson, students examine poverty both from a quantitative perspective, through data and graphs, and from a qualitative perspective, through stories and case studies.

Objectives

In this lesson, students will

- identify differences between developed and developing-country poverty;
- use data and graphs to explore regional trends in poverty and asset wealth;
- trace feedbacks between productive asset stocks, poverty duration and depth, resource productivity, and household well-being;
- develop strategies to combat structural poverty in the rural developing world;
- work with case studies that portray the human face of ultra-poverty; and
- work productively in groups.

Materials

- Handout 1, *Lesson Introduction (Refining Definitions of Poverty)*
- Handout 2, *Ultra-Poverty and Chronic Poverty*
- Handout 3, *Assets and Poverty Trends*

- Handout 4, *Assets, Structural Poverty, and the Rural Poverty Cycle*
- Handout 5, *Viewing Guide: Jeff Raikes Video Clip*
- Handout 6A, *Group Project Instructions*
- Handout 6B, *Group Project Case Study*
- Handout 6C, *Group Project Sample Report*
- Handout 7, *Quiz*
- (Optional) Handout 8, *Christopher Barrett Lecture Summary*
- (Optional) Handout 9, *Reading Guide: Christopher Barrett Lecture Summary*
- DVD, clip from *Greg Page and Jeff Raikes, "Improving Food Security in the 21st Century: What Are the Roles for Firms and Foundations?" Lecture delivered at Stanford University, February 10, 2011*. Complete lecture available online—instructor may choose to show additional content or to make the entire video available to students outside of class.
- Answer Key, *Lesson Introduction*
- Answer Key, *Assets and Poverty Trends*
- Answer Key, *Assets, Structural Poverty, and the Rural Poverty Cycle*
- Answer Key, *Viewing Guide: Jeff Raikes Video Clip*
- (Optional) Answer Key, *Reading Guide: Christopher Barrett Lecture Summary*

Equipment

- Video projector
- Internet-ready computers for student research (recommended for group project)

Teacher Preparation

Prior to teaching the lesson, instructors should:

- Review all handouts, and make the correct number of copies (one per student, unless otherwise indicated).
- Arrange the room for group work throughout the lesson. Note: students will work in groups of four to five throughout the lesson; the instructor may wish to form these groups prior to Day One.
- Prior to Day One, set up and test video projection equipment.
- Prior to Day One, watch the video clip and review the viewing guide and answer key. Recommended: Watch the Greg Page and Jeff Raikes lecture in its entirety to develop a complete understanding of the context for the clip.
- Prior to Day Two, arrange for student access to Internet-ready computers if possible.
- Review Handout 7, *Christopher Barrett Lecture Summary*, and Handout 8, *Reading Guide: Christopher Barrett Lecture Summary*. Determine whether these materials are appropriate for the class. The *Extensions and Excerpts* section provides suggestions for using these materials with students.

- Prior to Day Two, set up and test video projection equipment.
- Optional: Instructors may wish to consult the following papers, available on the Internet, for additional background on poverty topics. These materials may also be appropriate as reference sources for some advanced students.
    - o Ahmed et al, *The World's Most Deprived: Characteristics and Causes of Extreme Hunger*, Washington, D.C.: International Food Policy Research Institute, 2007. Chapter 2: "Global Poverty and Hunger: Location and Trends."
    - o Lipton, Michael, *Seasonality and Ultra-Poverty*, Institute of Development Studies, 1986.
    - o Haughton, Jonathan and Shahidur R. Khander, *Handbook on Poverty and Inequality*, Washington, D.C.: The World Bank, 2009. Recommended sections: Chapter 8, "Understanding the Determinants of Poverty," Introduction and Household and Individual-Level Characteristics. Available online from the World Bank: http://web.worldbank.org.

Time

The complete lesson requires at least three 50–minute class periods. Students also complete homework assignments prior to Day One and following Day Two. Suggestions for extending or shortening the lesson are provided in the *Extensions and Excerpts* section, below.

Procedures Before Day One

Explain to students that they will spend the next several class periods exploring the characteristics, causes, and consequences of poverty in the rural developing world. Note that the material in Part Two of Lesson Four builds on the knowledge of rural economics and that students gained in Part One, as well as on the basic understanding of poverty that they developed in Lesson One of this unit. Distribute Handout 1, *Lesson Introduction,* and ask students to read the handout and answer the graph analysis questions for homework. Also encourage students to review Lesson One, Handout 4, *Measuring Poverty and Hunger*; instructors may distribute additional copies of this handout to students, if necessary.

Day One

1. (10 minutes) Divide the class into groups of four or five students (five or six groups total). Students will work in these groups for the remainder of the lesson. Ask students to take out Handout 1, *Lesson Introduction,* and to spend a few minutes reviewing the handout questions in their groups—in particular, students should try to agree on the key implications of each graph. The instructor should circulate between groups to refine student responses (use the Answer Key to Handout 1 as a guide) and guide discussion.
2. (15 minutes) As students conclude their discussion of Handout 1, distribute one copy of Handout 2, *Ultra-Poverty and Chronic Poverty,* to each student. Explain that this handout includes more detailed

information on the trends that students have observed in the Handout 1 graphs. Ask students to read the text of the handout to themselves, and then to collaborate with their group to complete the brainstorming exercises, adding classmates' ideas to their own notes.

3. (5 minutes) Briefly bring the class back together, and ask each group to share one or two ideas from their brainstorming. Students should record new ideas from other groups in their notes on Handout 2.
4. (20 minutes) Explain to students that they will now begin a formal exploration of factors that help to explain regional differences in poverty. Distribute one copy of Handout 3, *Assets and Poverty Trends,* to each student. Ask students to complete the graph analysis questions in Handout 3 in their groups, and to discuss the two synthesis questions that follow, taking thorough notes on their own handout. Give students the remainder of the period to work on this assignment.
5. At the end of the period, distribute one copy of Handout 4, *Assets and Structural Poverty,* to each student. Ask students to read the handout and answer the short essay questions for homework. Note: To reduce students' workload, the instructor may choose to have students answer only one essay question, with at least one student in each group assigned to each question. Students may answer additional questions for extra credit.

Day Two

1. (10 minutes) Ask students to reassemble in their groups from Day One and to take out their responses to the Handout 4 questions. Give students a few minutes to review the handout in groups, resolving any questions with their classmates and the instructor. Note: If students did not answer all three questions, they should take careful notes on their classmates' responses on a separate sheet, and attach this sheet to the assignment to hand in.
2. (5 minutes) Inform students that they will now begin to explore possible solutions to rural structural poverty. They will begin by watching a brief video clip about an antipoverty program implemented by the Bill and Melinda Gates Foundation; then, they will move on to design their own antipoverty strategies. Distribute one copy of Handout 5, *Viewing Guide: Jeff Raikes Video Clip,* to each student. Give students a moment to look over the questions on the viewing guide.
3. (5 minutes) Play the clip from Raikes' lecture.
4. (15 minutes) Lead a class discussion of the video clip. Give students an opportunity to clarify unfamiliar vocabulary terms, and then ask students to volunteer responses to each of the *Viewing Guide* questions. Conclude the discussion by asking a few students to suggest questions for the speaker.
5. (15 minutes) Distribute one copy each of Handouts 6A, B, and C, *Group Project Instructions*, *Group Project Case Study*, and *Group Project Sample Report* to each student. Ask students to carefully review these handouts in their groups. Each group should complete the following

steps before the end of class:

a. Formulate a rough goal statement that addresses each question listed in the project instructions.

b. Divide tasks: Assign one or two group members to develop a list of possible project partners, one or two members to develop a list of progress metrics, and remaining group members to refine and formalize the draft goal statement. All group members should plan to complete these tasks for homework (students may need to meet in groups or pairs outside of class). Note: Be sure students understand that the narrative portion of the project is not a part of the initial group assignment.

c. At the end of class, inform students that they will have a short quiz on the material in Handouts 1–4 at the beginning of the next class period. Students should review these handouts in preparation for the quiz.

Day Three

1. (10 minutes) Distribute one copy of Handout 7, *Quiz*, to each student Give students about 10 minutes to work on the quiz, and then collect quizzes for evaluation.
2. (20 minutes) Ask students to reassemble in their groups. Inform students that they will have about 15 minutes to discuss the tasks that they completed for homework, and to prepare a brief presentation on their program for the class. Allow students to work in groups for 15–20 minutes; the instructor should circulate between the groups to resolve any questions about the project and presentations.
3. (20 minutes) Bring the class back together, and call each of the groups forward to present their work. Invite questions from the class following each presentation, if time allows.
4. When all groups have concluded their presentations, inform ask students to complete the Narrative portion of the project for homework, to be submitted at the beginning of the next class period.
5. At the end of class, collect the written project reports from each group. Make sure that students have access to electronic copies of their reports if they would like to reference them while working on the Narrative. Also collect Handouts 1–5 for evaluation.

Extensions and Excerpts

Extensions: Two supplementary handouts are included with the lesson materials: Handout 8, *Christopher Barrett Lecture Summary*, and Handout 9, *Reading Guide: Christopher Barrett Lecture Summary*. Handout 8 summarizes a university lecture on the topic of rural poverty traps; Handout 9 is intended to help students place the summary in the context of the lesson. These materials may be appropriate as lesson extensions for advanced students. Instructors may assign the summary as an extra-credit homework or in-class assignment at any point after students complete Handout 4, *Assets, Structural Poverty, and the Rural Poverty Cycle*. Instructors with advanced students who have limited time to devote to the lesson may also choose to read and discuss the summary in lieu of the video clip and/or the group project.

Excerpts: Instructors with less time to devote can shorten the lesson by omitting the Group Project. Administer the *Quiz* immediately following discussion of the video clip, and conclude the lesson at the end of Day Two. Instructors may also consider simplifying the group project by omitting the Partners and/or narrative sections of the report, or by asking students to suggest hypothetical "partner types" (as described in the project instructions) rather than researching actual organizations.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess student work on Handout 1, *Lesson Introduction,* based on
  - accuracy and completeness of the student's descriptions of the two graphs (questions 1 and 3; use the answer key as a guide);
  - completeness, accuracy, and creativity of the student's assessments of significant trends, correlations, and other key features of the two graphs (questions 2 and 4; use the answer key as a guide, but award credit for logical and insightful responses not included in the answer key suggestions); and
  - concision and accuracy of the student's final summaries (question 5); students' responses should include most of the points listed on the answer key.
- Assess student work on Handout 2, *Ultra-Poverty and Chronic Poverty,* based on the level of detail, creativity, and logical insight in the student's responses to the brainstorming questions.
- Assess student work on Handout 3, *Assets and Poverty Trends,* based on
  - accuracy and completeness of the student's descriptions of the three graphs (question 1 for each graph; use the answer key as a guide);
  - completeness, accuracy, and creativity of the student's assessments of significant trends, correlations, and other key features of the graphs (question 2 for each graph; use the answer key as a guide, but award credit for logical and insightful responses not included in the answer key suggestions); and
  - the level of detail, creativity, and logical insight in the student's responses to the discussion questions.
- Assess student work on Handout 4, *Assets, Structural Poverty, and the Rural Poverty Cycle,* based on
  - accuracy and completeness of the student's responses to the handout questions (note that some questions are intended to be open-ended; consult the answer key for specific suggestions for evaluating student responses); and
  - the student's demonstrated ability to organize responses in clear,

concise sentences and paragraphs, using appropriate vocabulary and correct grammar.

- Assess student work on the Group Project based on:
  - o Goal statement:
    - Does the goal statement mention specific asset(s), target populations, training and support services, and success criteria?
    - Are the goal and methods appropriate and realistic in the context of the case study scenario?
    - Is the goal statement clear and concise? Did the group use formal language, appropriate vocabulary, and correct grammar?
  - o Partners:
    - Has the group thought broadly and creatively about the needs of the project and the possible partners (or partner types) who can fill those needs? Each group should list, at a minimum, three possible partners.
    - Is the list annotated with a detailed, logical description of why the group chose each partner and what they hope that the partner will bring to the project?
  - o Progress metrics:
    - Does the group list at least three specific metrics?
    - Are the metrics expressed in relative quantitative terms (50 percent enrollment, 100 percent increase, etc.)?
    - Has the group chosen creative metrics that can be easily monitored, and that will provide objective, relevant insight into the success of the project?
  - o Narrative:
    - Does the narrative reference a specific individual or household as described in the instructions?
    - Does the narrative incorporate each point listed in the instructions (before and after description, detailed description of program services, future goals, and challenges, success metrics, and quotes)?
    - Does the author demonstrate an understanding of the case study and an ability to trace logical feedbacks between problems, actions, and outcomes?
    - Is the narrative well organized and written with attention to style and clarity? Does the author use appropriate vocabulary and correct grammar?
    - Is the narrative insightful, creative, and engaging?
  - o Overall:
    - Does the project reflect effective group collaboration?
      - Did the group members divide tasks efficiently to achieve equal strength in all sections of the report?
      - Do all group members list the same goal statement, partners,

and progress metrics on their individual reports?

- Are group members' reports neatly formatted to approximately match the sample?
- Is the overall proposal creative, realistic, and relevant to the case study?

- (Optional) Assess student work on Handout 9, *Reading Guide: Christopher Barrett Lecture Summary*, based on
  - o the level of detail, accuracy, and logical insight in the student's responses to the reading guide questions (use the *Answer Key* as a guide, but note that student responses to open-ended questions are not expected to match the guide exactly);
  - o the student's demonstrated ability to explain statements and concepts in their own words, using appropriate examples and vocabulary from the lesson; and
  - o the extent to which the student's responses connect Barrett's ideas to concepts covered in this and previous lessons.
- Assess students' participation in group work and class discussion throughout the lesson based on:
  - o accuracy and appropriateness of contributions;
  - o clear and succinct statement of comments, questions, and answers;
  - o attention to other students' questions and ideas;
  - o ability to follow and promote lively, productive discussion;
  - o open-mindedness and respect for other students' backgrounds and opinions;
  - o willingness and ability to incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
  - o willingness and ability to express confusion and request clarification from other students and the instructor.

Lesson Introduction (Refining Definitions of Poverty)

In Lesson One, you learned about basic metrics used to measure poverty, such as the poverty headcount and the poverty gap. You also learned how various "cutoff" household expenditure levels, called poverty lines, are used to define poverty at local, national, and international scales. Most importantly, you observed the strong positive correlation between poverty and food insecurity—where poverty rates are high, hunger and malnutrition are likewise prevalent, and access to food tends to be both inadequate and unstable.

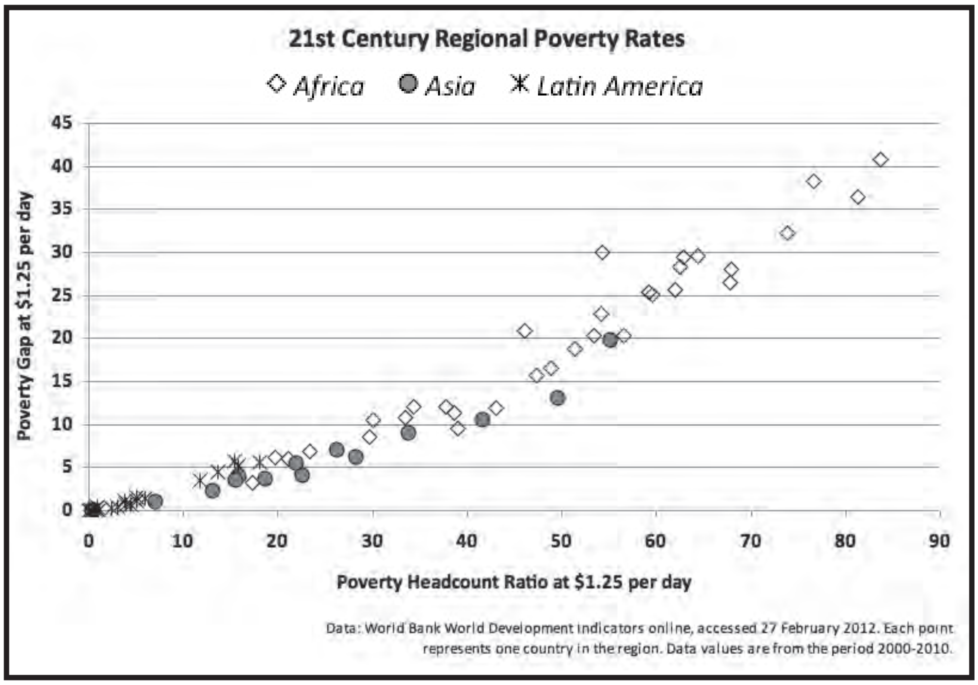
In this lesson, you will study the connections between poverty and food insecurity in greater depth. You will begin by refining your definition of "poverty" to better describe differences in poverty trends between countries and regions. With your classmates, you will then work to understand the causes of poverty in both developed and developing countries. You will learn how poverty and food insecurity deepen through mutually reinforcing feedbacks, and how productive assets affect a household's prospects for transitioning into or out of poverty over time.

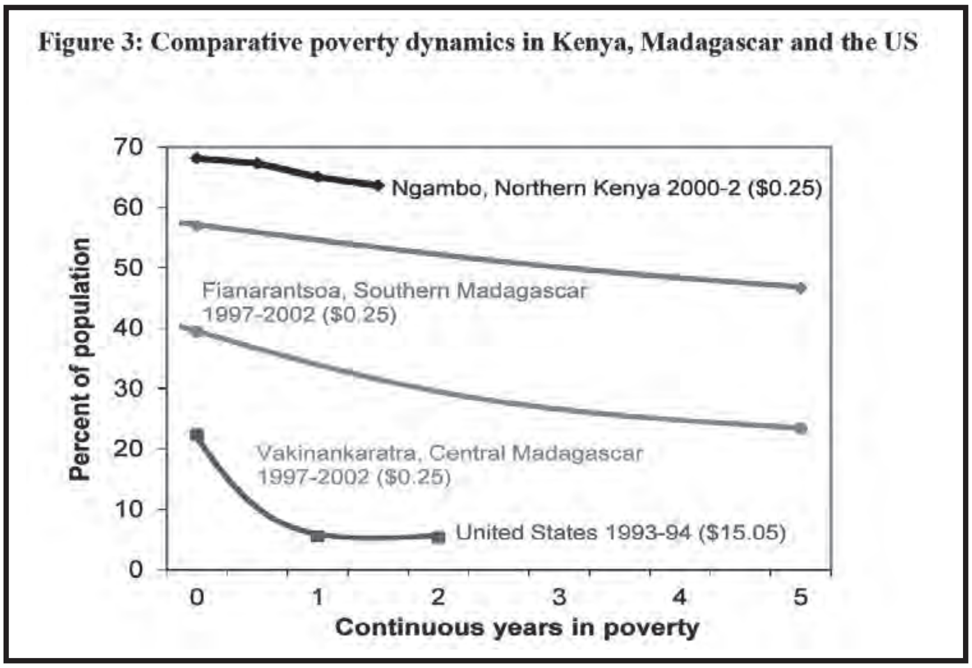
As you explore the features and causes of rural poverty, you will consider how your observations might inform efforts to improve food security in developing countries. At the end of the lesson, you will have a chance to apply your knowledge and ideas to design an antipoverty strategy or program for the regions you have studied.

By the end of the lesson, you should be able to define and explain the following terms:

- ultra-poverty
- chronic poverty
- transitory poverty
- productive asset
- structural poverty
- stochastic poverty

You will begin by investigating regional differences in the *depth* and *duration* of poverty. Study the graphs on the next page carefully, and do your best to answer the questions that follow. You will discuss this material in class; as you work, make a note of any comments or questions that you would like to share with your instructor and peers.





Source: Barrett, Christopher. "Assisting the Escape from Persistent Ultra-Poverty in Rural Africa." Stanford, CA: Stanford Center on Food Security and the Environment, 2011.

Questions:

1. Describe the first graph in a few short sentences. What do the axis labels mean (recall Lesson One), and what are the units of each axis? What does each point represent, and what do the different styles of point signify? Where did the data used to construct the graph come from?

2. What trends do you see in the first graph? Do the variables on the axes appear to be correlated? Are the points grouped in any significant way? Summarize the implications of the graph in one or two clear, concise sentences.

3. Describe the second graph in a few short sentences. What are the measures and units shown on each axis? What do the different lines represent? Where did the data used to construct the graph come from?

4. What trends do you see in the second graph? Do any differences or similarities between the four plotted lines strike you as important? Do the variables on the axes appear to be correlated? Summarize the implications of the graph in one or two clear, concise sentences.

5. Summarize the most important implications of both graphs in a single sentence.

ULTRA-POVERTY AND CHRONIC POVERTY

In Lesson One, you learned that poverty at the $1.25 per day level is concentrated in sub-Saharan Africa and South Asia, with Asian countries harboring the largest numbers of poor people while African countries have the highest poverty rates. The graphs shown in Handout 1 illustrate two additional characteristics that distinguish African poverty, in particular, from poverty in other regions of the world:

1. African poverty is *deeper* or *more extreme* than poverty in other developing regions. In many African nations, a majority of households live not just below the $1.25 per day international poverty line, but far below it—as little as $0.75 or even $0.25 per day. Referring to Handout 1, we can observe the depth of African poverty by reading the poverty gap off the y-axis of the first graph (recall that the poverty gap describes the average poor household's distance below the poverty line as a percentage of that poverty line, so that a gap of 40 percent means that the average poor household lives on $1.25 – 0.4*$1.25 = $0.75 per day). We can also look at the second graph, which shows extreme poverty rates of up to 75 percent at $0.25 per day in a few selected African communities.

Brainstorm: *Why do you think that African poverty is more extreme than poverty in other regions? Suggestion: Think about the possible causes of poverty in each region and how they might affect poverty depth.*

ultra-poverty—a state of especially deep poverty; the "poorest of the poor." May also refer to various quantitative definitions, e.g., less than $0.50 per day, food consumption below 80 percent of energy requirements, etc.

Economists, governments, and development organizations sometimes use the term ultra-poverty to describe a state of especially deep regional or local poverty. In general, the term refers to the "poorest of the poor"; poverty scholars have also proposed various quantitative definitions. In a 2007 study on extreme poverty and hunger, for example, the International Food Policy Research Institute defined the ultra-poor as those who live on less than $0.50 per day.[5] British economist Michael Lipton, who is thought to have first used the phrase *ultra-poverty* in a 1986 paper, defined the ultra-poor as "a group of people who eat below 80 per cent of their energy requirements

5 Ahmed et al. *The World's Most Deprived: Characteristics and Causes of Extreme Poverty and Hunger*. Washington, D.C.: International Food Policy Research Institute, 2007.

despite spending at least 80 per cent of income on food."[6] More recent work by Professor Christopher Barrett of Cornell University used a cutoff of one-half the World Bank's international poverty line, or $0.62 per day.[7]

Whatever the exact definition, ultra-poverty demands attention—at expenditure levels below $1 per day, every penny matters, and ultra-poor households may experience much more pronounced shortages of food and other essentials compared with those who live at or just above the international poverty line. You will consider the causes and consequences of ultra-poverty in greater detail in the remainder of this lesson.

2. African poverty lasts longer than poverty in other regions. Again referring to Handout 1, we can see from the second graph that African poverty lasts much longer, at a much more extreme level, than poverty in the United States (note: the graph shows the percentage of the population, on the y-axis, that remained poor for a certain period of time, on the x-axis—so the point (2,30) indicates that 30 percent of the population remained poor for at least two years during the study period). Poverty in the U.S. tends to be transitory—short-lived—while poverty in Africa tends to be chronic, or persistent.

transitory poverty—poverty that occurs in short spells (a few months or less)

chronic poverty—persistent poverty, enduring for years, decades, or generations; contrast with transitory poverty

Brainstorm: *Why do you think that African poverty is more persistent than U.S. poverty? Again, think about whether differences in the cause of poverty could account for differences in its duration.*

The graphs in Handout 1 are excerpted from a paper by Professor Barrett. In the paper, Barrett elaborates on the significance of the data show in the second graph:

> *"Figure 3 (adapted from Barrett and Swallow 2006) contrasts poverty dynamics in the United States (Naifeh 1998) with that in three rural African sites my collaborators and I have observed…These are very crude comparisons*

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6 Lipton, Michael. *Seasonality and Ultra-Poverty*. Institute of Development Studies, 1986.
7 Barrett, Christopher. *Assisting the Escape from Persistent Ultra-Poverty in Rural Africa*. Stanford: Stanford University Center on Food Security and the Environment, 2011.

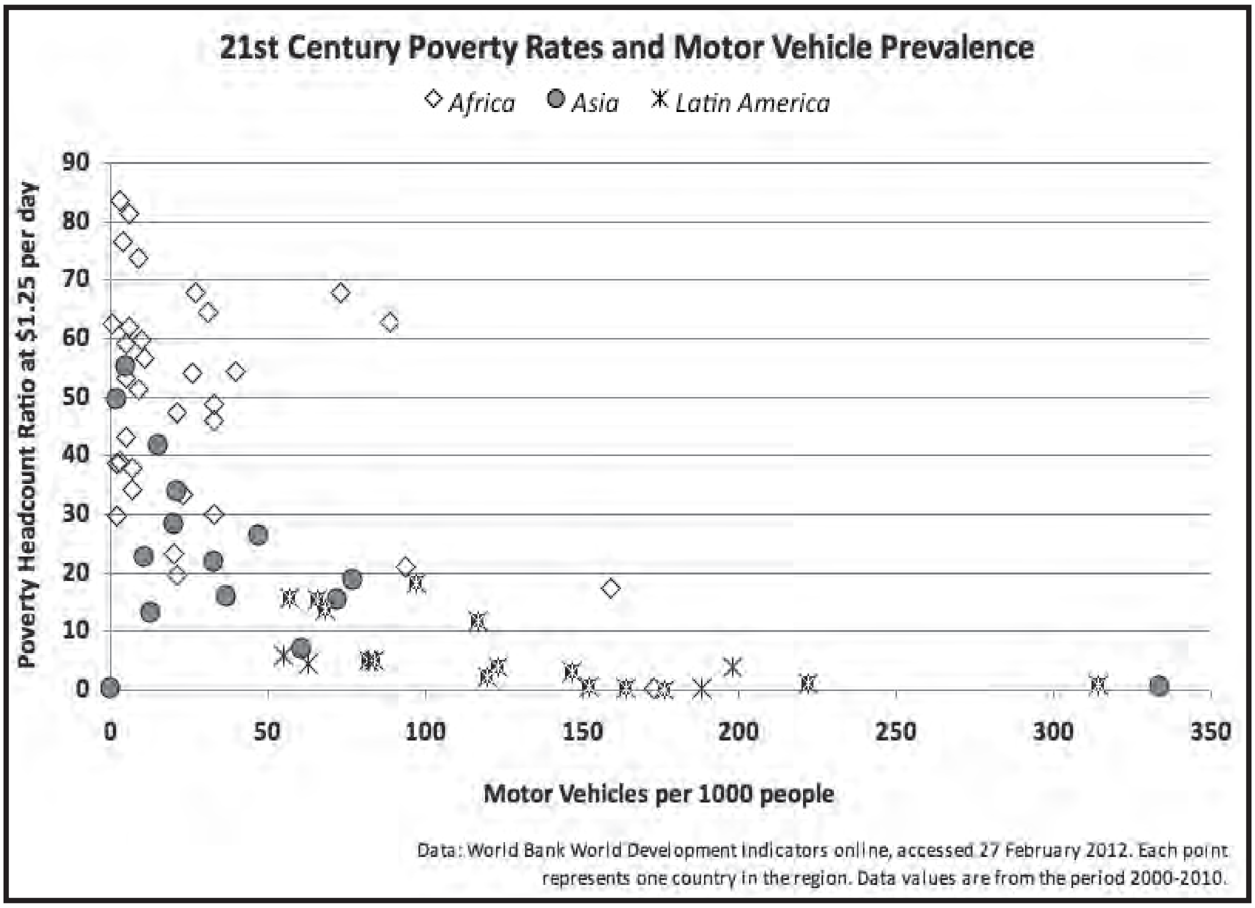
> *meant purely for illustrative purposes. But they clearly make the key qualitative point that the percentage of the population that was poor at one point in time…who remain poor in subsequent periods falls very quickly in the United States, where most poverty is transitory…In the U.S., less than 25 percent of the households remained poor for one year and only 5.3 percent were still poor after two years; median time in poverty was only 4.5 months (Naifeh 1998).*
>
> *By contrast, most poverty in these African cases appears distressingly persistent. Anywhere from 60 to 90 percent of the ultra-poor—the poverty lines used here were half the national rural poverty lines in place at the time—remained ultra-poor 18 to 60 months later. In rural Africa, we do not even know the median spell length in poverty! That is because we have no longitudinal data sets in which at least half of the initially poor have exited poverty in some subsequent round, so we cannot compute the median poverty spell length."*[8]

Barrett's results suggest a fundamental and critically important distinguishing feature of African poverty—while poverty in a developed country such as the United States can easily be temporary, poverty in rural Africa may be a life sentence. In the remainder of this lesson, you will explore the factors that underlie chronic poverty in the rural developing world.

8 *Ibid.*

Assets and Poverty Trends

The graphs below show World Bank data related to a few different factors—motor vehicle prevalence, literacy, and rainfall—alongside poverty data, for several countries in the developing world. Study the graphs carefully, and answer the questions that follow.

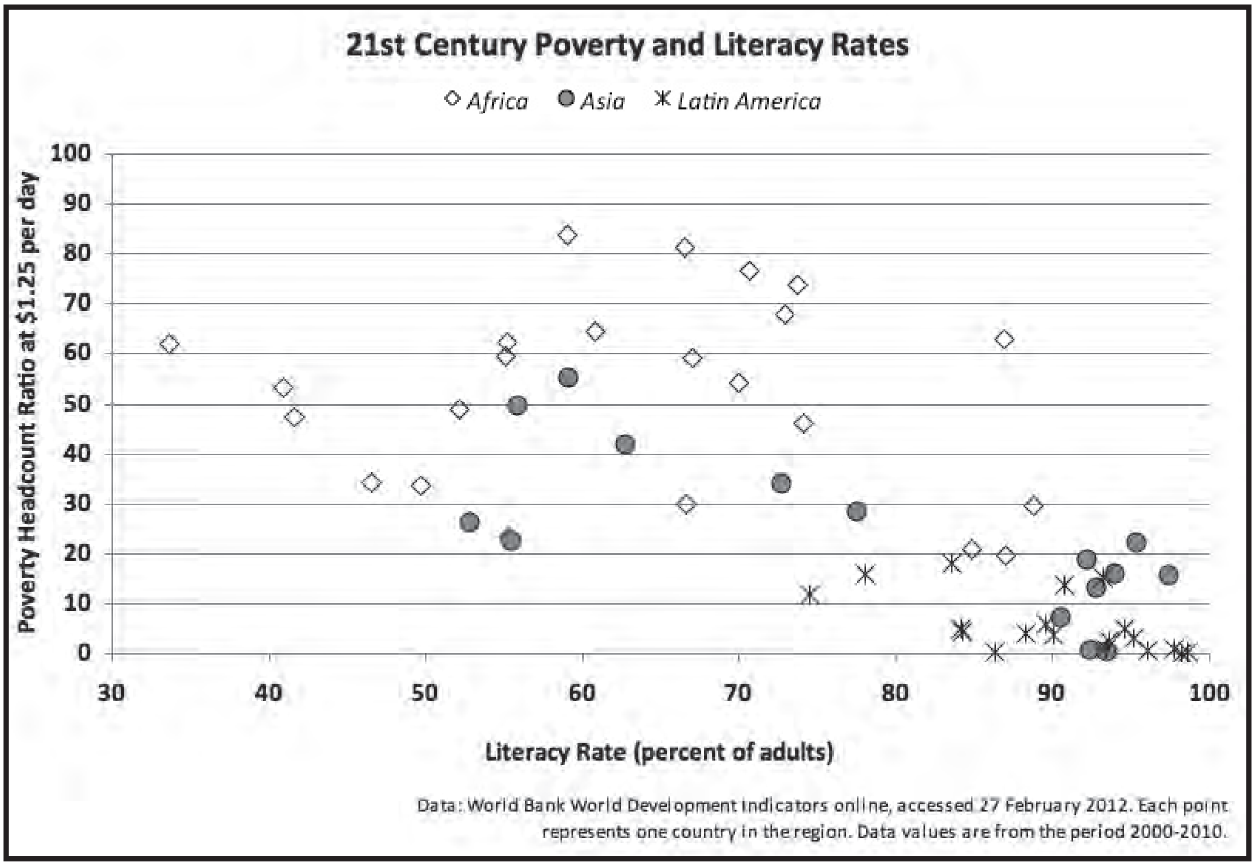


Graph #1: Poverty and Motor Vehicle Prevalence

Questions:

1. Describe the graph. What are the values and units on each axis? What does each point represent?

2. Do you see any trends in the graph—correlation of variables, clustering of points, etc.? Describe the trends you see, and summarize their significance (i.e., the key point made by the graph) in a sentence.

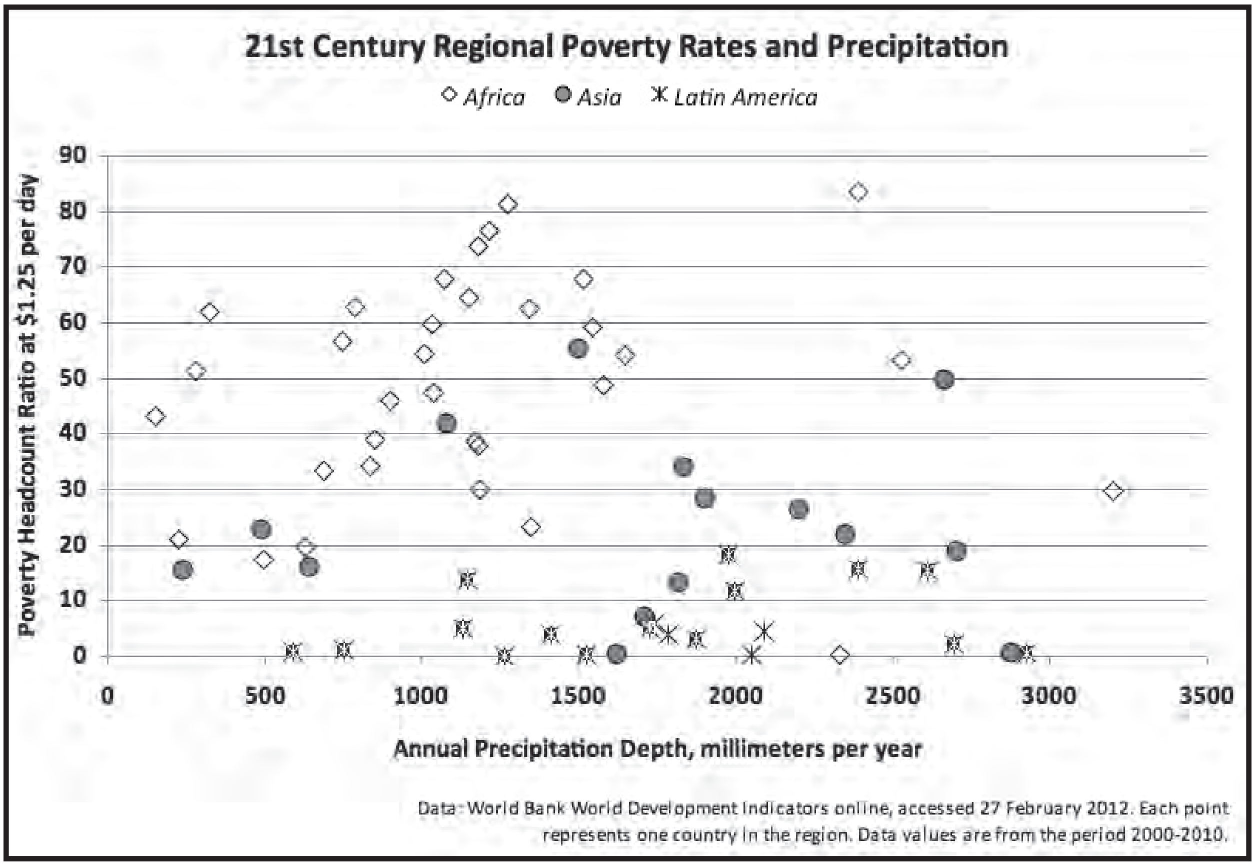


Graph #2: Poverty and Literacy

Questions:

1. Describe the graph. What are the values and units on each axis? What does each point represent?

2. Do you see any trends in the graph—correlation of variables, clustering of points, etc.? Describe the trends you see, and summarize their significance (i.e., the key point made by the graph) in a sentence.



Graph #2: Poverty and Literacy

Questions:

1. Describe the graph. What are the values and units on each axis? What does each point represent?

2. Do you see any trends in the graph—correlation of variables, clustering of points, etc.? Describe the trends you see, and summarize their significance (i.e., the key point made by the graph) in a sentence.

For discussion:

1. Describe any differences between the trends you saw in the three graphs (e.g., varying degrees of correlation between variables, clustering of points, etc.). How would you explain these differences?

2. What do the three factors shown in the graphs above—vehicle prevalence, literacy, and precipitation—have in common, beyond any apparent correlation with poverty rates?

Assets, Structural Poverty, and the Rural Poverty Cycle

Vehicle ownership, literacy, and precipitation may seem to be wholly disparate factors, but they are united by a common theme: Each enhances its owner's capacity to earn income. A farmer who owns a car or truck can more easily transport inputs to the field and crops to local markets. If the same farmer can read and write, he or she can keep better financial records, stay informed about market trends, and perhaps even pursue off-farm employment opportunities. And if the farmer's region receives regular, adequate rainfall, he or she—along with many other farmers—will achieve higher yields with less effort and expense.

productive asset—a physical item, or a characteristic of a person or group, that has monetary value or income-generating potential

Economists use the term productive asset to refer to a physical item, or a characteristic of a person or group, that has monetary value or income-generating potential. Rainfall, motor vehicles, and education are all productive assets. Other examples could include soil nutrients, seed, and fertilizer; labor and farm machinery; and buildings for housing animals or storing crops. Good health is a productive asset, as healthy people are able to work harder and more productively. Money itself is a productive asset, as it can be invested in various ways to yield more money.

Productive assets—or the lack thereof—play a key role in determining the depth and duration of poverty. Consider, for example, a farm household that relies on less than one productive asset—land—for its livelihood and sustenance. Imagine that the household has only a small plot of farmland, perhaps a hectare (one square kilometer) or so, and few other income-generating assets—its members are uneducated and own no vehicles or farm animals.

In an effort to maximize the plot's productivity, the household may plant crops close together or grow multiple crops in a single season. In the short term, these practices may slightly increase the household's food supply. But in the long term, without fertilization—which we assume this household cannot afford—high-intensity farming will deplete the soil of nutrients, leading to declining crop yields (recall Lesson Two). The household could restore the soil by allowing the land to rest unplanted for a season or two—but as their crops are their primary food source, doing so would mean severe short-term hunger.

Instead, the household will devote all of their resources to producing and acquiring food. Younger members will work on the farm instead of attending school. Surplus income will go toward buying staple foods at the market for consumption now, rather than toward uncertain investments in fertilizer, irrigation, or farm animals that could yield great returns in productivity in future years. As household members work harder and the quality of their diet declines, they will become more vulnerable to injury and illness, and the household may face a harsh choice between buying medical supplies or food.

The household in this example is poor because they lack the productive

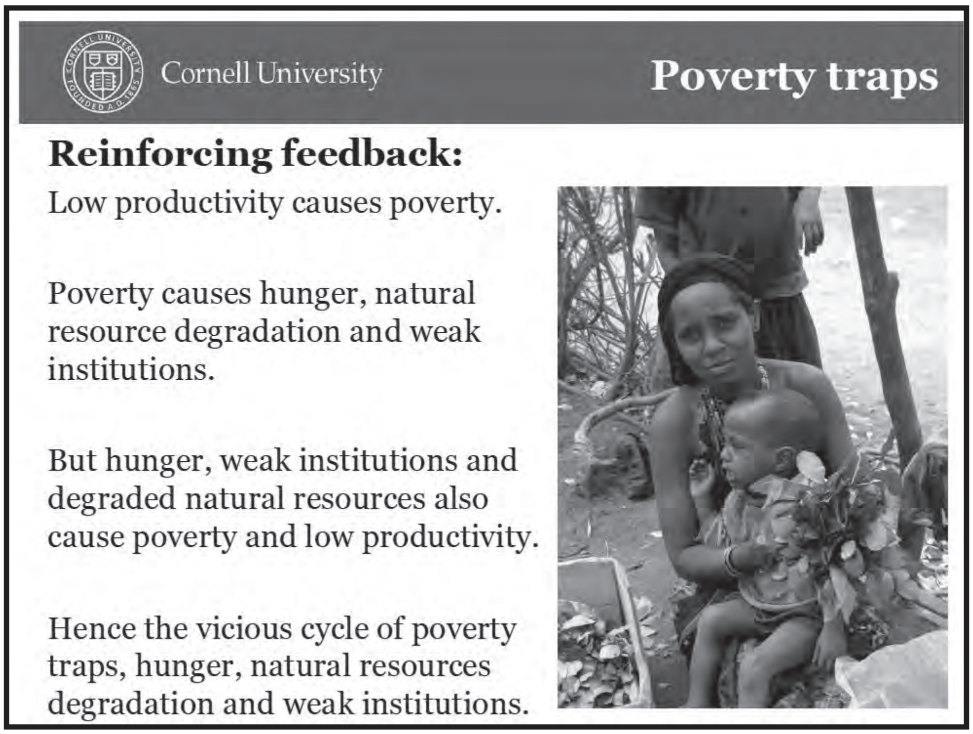
structural poverty—poverty that results from a fundamental lack of productive assets

assets to generate adequate, sustainable income. We can say that such a household is structurally poor—their poverty stems from weaknesses in the fundamental structure of their resource base and way of life. As demonstrated by the example above, structural poverty can lead to a vicious downward spiral: a structurally poor household will exploit their minimal assets to the point of extreme degradation and then slip further into poverty as the productivity of those assets declines. Rural households are especially vulnerable to this poverty trap effect, as they tend to rely heavily on natural assets—land, water, animals, etc.—that, unlike human and capital assets such as education and machinery, can be severely depleted if used intensively for an extended period of time.

stochastic poverty—poverty that results from chance events (unemployment, weather or health shocks, etc.) in the presence of adequate asset wealth

Contrast the example above with the case of a developed-country household that becomes poor because of the loss of a job. This household is stochastically poor[5]—their poverty results from a chance event, and given that the household members possess the same stock of productive assets as prior to the event (e.g., certain qualifications for employment, such as education and experience), they have a good chance to recover in the space of a few months. Stochastic poverty therefore tends to be mild and transitory relative to structural poverty, which is often chronic and extreme.

The slide below, excerpted from a presentation by Professor Christopher Barrett of Cornell University, summarizes the typical cycle of a rural structural poverty trap:



[5]*Stochastic* means random or chance.

In general, structural poverty has a simple solution: Provide the rural poor with the assets that they need to increase their productivity. Consider, for example, the potential impact of giving the household in the example above a second one-hectare plot of land. The household could rotate the two plots each year, allowing the soil in one plot to recover while growing food on the other plot. Yields would improve. Eventually, the small farm might produce enough for its operators to sell some of the crop, generating income that they could use to pay school fees or to purchase fertilizer, animals, and farm machinery. These new assets would continue to increase income and productivity, and the household would be well on its way to exiting poverty.

Questions

Answer the following questions on a separate sheet of paper. Each answer should be in the form of one or two well-organized short paragraphs (no more than 150 words in all), written in complete sentences using appropriate vocabulary and correct grammar.

1. Consult an online source for a definition of *institution* (you will find several—choose the appropriate definition for this context). Explain the role of institutions in the poverty trap cycle (i.e., explain how weak institutions lead to poverty and vice versa).

2. Choose a productive asset (not land) from the examples given in this handout or from your own experience. Explain:
   a. Why your choice is a productive asset (refer to the definition above); and
   b. How an inadequate stock of this asset could push a household into a poverty cycle.

3. The term *poverty cycle* implies that any of the factors listed in Barrett's slide could initiate a negative feedback loop. Describe a scenario in which another of these factors, such as hunger or resource degradation, could initiate the poverty cycle.

VIEWING GUIDE: JEFF RAIKES VIDEO CLIP

In this lesson, you have learned about productive assets and their important role as determinants of structural poverty. You will now watch an excerpt from a presentation by Jeffrey Raikes, CEO of the nonprofit Bill and Melinda Gates Foundation. In this clip, Raikes describes one Gates Foundation project that helped small dairy farmers in Africa climb out of poverty through the provision of a few well-chosen productive assets.

Read through the questions below before watching the video, and make brief notes on this sheet as you watch. You will have a chance to refine your answers before turning them in.

As you answer the viewing guide questions, also think about the overall design of the Gates Foundation project. Why did the foundation choose to fund provision of these assets in particular? At what level (individual/household/community/region/etc.) did they implement the project, and why? How did they ensure that gains from the project would be self-sustaining and self-increasing?

1. The project that Raikes describes in this clip centers around a *dairy chilling plant*. Use the context that Raikes provides to formulate a description of what these plants do and why they are important to small farmers. Write your description below.

   a. What is a dairy chilling plant?

   b. Why are these facilities important to small farmers?

2. According to Raikes, the chilling plant project involved several different types of investment to assist farmers. List the three general categories that Raikes mentions:

3. Because of the dairy chilling plant, farmers can now receive a ______________________ for milk.

4. The stability provided by the dairy chilling plant gave farmers an incentive to invest in ________________________.

5. Raikes mentions several specific services in addition to dairy chilling that the plan provided for farmers. List those services:

6. In Raikes's experience, when poor farmers are able to increase their income, they almost always invest first in ________________________________.

Unfamiliar terms:

Questions about the lecture/for the speaker:

Group Project Instructions

As you have learned in this lesson, **productive assets**—such as land, machinery, and education – act as major determinants of poverty in the developing world. A household with an insufficient stock of these assets may enter a downward spiral into **structural poverty**, characterized by steady loss or degradation of existing assets and ultimately leading to a state of extreme, chronic deprivation. Conversely, a household with an adequate asset stock can afford to make investments that will protect and improve their long-term productivity. This household will enter an upward spiral, continually increasing their income and improving their wellbeing.

In this exercise, you will apply your understanding of structural poverty to develop an anti-poverty program for a specific case study scenario. Your teacher will provide you with a description of the scenario you are to use. Study the scenario carefully, and then work with the other members of your group to design a program aimed at alleviating poverty in this particular scenario. As a part of your strategy, you should plan to provide the affected population with one or more productive assets.

You will present your strategy as a hypothetical "progress report"—a one or two page document, written from a postimplementation perspective, summarizing the goals of your program and its results during the first few years of implementation. Use the Gates Foundation brief "Profiles of Progress: East Africa Dairy Development Project" as an example. Your finished group document should include the following:

- Goal statement: A clear, concise statement of your objectives and your means of achieving them. Your goal statement should address the following questions:
    - What asset(s) will you provide, and in what quantity (one per household, etc.)?
    - At what level will you provide the asset(s) (i.e., will you work with households, village/community leaders, or regional/national governments)?
    - What training or support services will you provide to help your target population make the most of these asset(s)?
    - What general metric will you use to measure the success of your project (income growth, yield gains, etc.)?
- Partners: Will you need to work with government organizations, nonprofit foundations, or private businesses? Consider your needs for:
    - funding;
    - local knowledge, connections, and buy-in; and
    - technical expertise.

Note: List specific organizations where possible; at a minimum, describe organization types and services, e.g., development foundations will provide funding, private businesses will donate vehicles, etc. Think broadly and be creative—list as many possible partners as you can! Annotate your list with a brief summary of why you believe that each partner or partner type can and should contribute a particular service.

- Progress metrics: List three or four specific, measurable outcomes that will indicate that your program is on track to achieve its objectives. You should use relative quantitative statements (e.g., doubled production, enrolled 50 percent of the population, etc).

You will need to divide the components of your project among the members of your group; you may turn in each component on a separate sheet, but you should coordinate you're your group-mates to ensure that your language and formatting is consistent. You should also prepare (as a group) to summarize your program for your classmates in a two or three minute presentation, focusing on your goals, general methods, and potential challenges or stumbling blocks. Your instructor will give you additional guidelines for dividing tasks, and you will have time in class to meet as a group while you are developing your program concept and final presentation.

After you have submitted the group document, you will work individually to craft a Program Narrative, an engaging, creative summary of your program's impact, anchored in a description of positive impacts on one individual or household (you will most likely reference the family in the case study summary). Your narrative should be about 500 words in length and should:

- contrast the household's/individual's situation before and after program implementation;
- describe program services in greater detail (compared with brief summaries in the goal statement), and explain their value to the household/individual;
- identify future goals and challenges for individuals/households and the program as a whole;
- mention at least one quantitative success metric; and
- include at least two "quotes" from officials and participants evaluating the program's success.

Group Project Case Study

Adapted with permission from the International Food Policy Research Institute. Source: Ahmed, Akhter U., R. Vargas Hill, L.C. Smith, D. M. Wiesmann, and T. Franenberger. 2007. The World's Most Deprived: Characteristics and Causes of Extreme Hunger. 2020 Discussion Paper 43, Box 4.1. Washington, D.C.: International Food Policy Research Institute. This paper can be found at: http://www.ifpri.org/sites/default/files/pubs/2020/dp/vp43/vp43.pdf.

Note to students: This case study scenario describes one specific household affected by poverty. Your antipoverty program should target the village (Chilmari Thana, described as "one of the most distressed areas of Bangladesh") in which this household resides.

Poverty and Hunger in One Family

Abdul Karim, about 35, is the head of a landless household. He lives with his wife, Ayesha, and their three children in Puthimari village of Chilmari Thana, one of the most distressed areas of Bangladesh. Abdul's household is among the many severely poor households in the village that were not covered by any government intervention program. The household was included in the control group of IFPRI's consumption and nutrition survey.

IFPRI—the International Food Policy Research Institute, an agricultural research and development organization

Abdul's one-room house, with walls made of kash (a tall, wild grass) and bamboo and a roof of straw, is too small for his family. It is clear that the household is in subjacent poverty. The severity of the family's malnutrition is evident from their skeleton-like features.

subjacent poverty—a level of poverty defined by IFPRI: per–person consumption expenditure between $0.75 and $1 per day

IFPRI field investigators Zobair and Farzana interviewed Abdul and Ayesha. "You can see our miserable condition. Yet we are not included in any of the government programs," Abdul said bitterly. "It is true that most of those who are getting rations are also poor, but none of them are as needy as we are."

"Two days ago, I worked on a neighbor's land, weeding his radish field. He gave me 5 taka, and a meal of rice and dal for the whole day's work," Abdul continued. "Yesterday, I went to him again, but he offered me only 3 taka and a meal. I accepted and worked from morning till evening." The day IFPRI visited the Karims, nobody in the family could find any work. Abdul had spent his 8 taka to buy about a kilogram of wheat, which Ayesha was frying in an earthen pot. "I soaked the wheat in salt water before frying," she said. "The wheat becomes hard and brittle after frying. This fried wheat is all we have for today's meal. From this, I have to save some for tomorrow also; we don't have money to buy more wheat or rice. Nobody wants to hire me or my husband for work because we are so weak. But if we can't find work, then we can't eat, and without eating we will become weaker."

taka—Bangladeshi unit of currency

Abdul nodded. "She is right. Aswin and Kartik [months in the lean

aman—the largest Bangladeshi rice harvest, which occurs in November

parboil—partially boil, or boil quickly

season] are the most difficult months. Many children in this area die during this time. They are so weak that even simple diseases kill them," he said, looking at his own children. "But things will improve after a month during the aman rice harvest. Everybody will get work. Ayesha will parboil paddy and husk rice in farmers' houses."

"But what will happen to us next? The river will probably take away our house next year," said Ayesha anxiously. "We were not this poor when we got married. We had some land, and we produced enough rice for our small family during that time. But one night, there was a big land erosion and the rakkushi [a legendary animal, like a dragon] river swallowed our land. Except this house, we have nothing left now. Last month, I sold my gold nose pin to a neighbor for one-fourth the price my husband paid for it. With that money we bought some rice and wheat."

Abdul sold a mango tree earlier in the month for only 100 taka. "The tree could easily fetch 500 taka," he said. "Big and sweet mangoes used to grow on that tree. But the man who bought the tree cut it for firewood because it could go into the river during the next flood. You see, the river is the cause of all our misery," Abdul concluded.

As the interview ended, Biplab, Abdul's eight-year-old son, came running with a large and beautiful water hyacinth flower in his hand. He gave the flower to Farzana and said shyly, "Please come again." Farzana had managed to hold her tears during the interview. She could not hold them any longer.

Source: Ahmed (2000b).

Group Project Sample Report

Bill & Melinda Gates foundation

EAST AFRICA DAIRY DEVELOPMENT PROJECT

PROFILES of PROGRESS

Paul Kimeni Muchai participates in the East Africa Dairy Development Project. The project provides training, veterinary care, financial services, and access to a chilling plant—allowing farmers to pool their milk and increase their income (Kenya, 2011).

Paul Kimeni Muchai's quiet character belies his ambition. A 40-year-old farmer with a wife and three children, Paul lives just outside Ol Kalou in central Kenya. He owns three dairy cows and a tidy three-acre farm where he grows fodder for his livestock and potatoes, beans, peas, and maize for his family.

While his farm functions well and his cows produce enough milk to support his family, he has bigger plans: to own a large herd and buy more land. Dairy farming is a way of living with so much promise, Paul explains, that he hopes his son follows in his footsteps.

Heifer International's East Africa Dairy Development (EADD) Project has helped bring Paul this hopeful future.

About 15 years ago, Paul had left Ol Kalou and moved to Mombasa, where he sold scrap metal. Unsatisfied, and looking for a better life, he moved home to become a farmer like his father. In Mombasa, says Paul, there was no investment in his future, and no way to improve his life.

> Since the project began, EADD has sold **304,000 liters of milk a day** through chilling plants (a 102 percent increase from 2009).

> **"Dairy farming is a way of living with so much promise, I hope my son will follow in my footsteps."**
>
> —Paul Kimeni Muchai, Kenyan dairy farmer

When he first started raising dairy cows, it was challenging. The hardest thing was getting the knowledge and money to help them produce more milk. When he learned about the EADD, and the benefits of joining the Ol Kalou Dairies Cooperative, he signed up. And it has paid off. Today, his cows produce ten kilos of milk a day—more than double what they produced before.

"I have learned so many things about farming and about how to feed and maintain the health of my cows," says Paul. "It's helped me very much."

Paul is just one of the nearly 173,000 farmers in Kenya, Rwanda, and Uganda who have benefitted from being part of an EADD-established cooperative. These cooperatives are the glue that holds the farmers together. Through cooperative "hubs," farmers receive training on how to take care of their livestock, and

Left: Francis Mwangi and Paul Kiama delivering milk to the Ol Kalou chilling plant. Center: Consolidating milk for distribution. Right: Joseph Ong'ang'a Mtulah, manager of the Ol Kalou chilling plant. (Kenya, 2011)

East Africa Dairy Development Project

Goal: To help dairy farmers in East Africa double their dairy-related incomes by increasing their ownership of cross-bred cows, increasing the amount of milk their cows produce, and strengthening their relationship to formal markets so they can sell more milk.

Countries: Kenya, Rwanda, and Uganda

Progress: Since starting the project, EADD has:

- registered 57 dairy business associations, with 172,000 members
- sold 304,000 liters of milk a day through chilling plants (a 102 percent increase from 2009)
- performed a total of 181,000 inseminations (82,000 in 2011 compared to 5,000 in 2008)

Partners: Heifer International, TechnoServe, International Livestock Research Institute, African Breeders Services, and World Agroforestry Center

www.heifer.org/ourwork/success/dairy

services including artificial insemination and veterinary health care. Financial services through the co-op give them much-needed access to money that they can invest in their farms. Cooperative-hosted chilling plants collect milk from farmers in the area, and it is sold in bulk to the growing formal market. By pooling their milk, farmers can get more for it.

It's this reliable place to sell their milk that makes all the difference to farmers like Paul, explains EADD team leader Ambrose Munene. This reliability of selling and receiving payment is as powerful as the cooperatives themselves. "When these groups get together, they can inspire each other to be accountable," says Ambrose, "and there's even a sense of competition among the farmers to be 'the best.'"

With the additional income he earns from the increased milk production, Paul has made improvements to his home and farm—buying furniture, plastering his house's walls, building a shed for the animal feed, and reinforcing the fences.

Improvements like this can be seen throughout the community, explains EADD's Ambrose. Like Paul, others have upgraded their homes and farms, and more children are in school because families have money to pay for their children's school fees. The nearby town is vibrant with new banks and stores.

"Now, people are thinking of farming as an investment, and a business," says Ambrose.

Quiz

1. Define the following terms:
   a. Ultra-poverty

   b. Chronic poverty

   c. Transitory poverty

   d. Structural poverty

   e. Stochastic poverty

2. Which of the following has been used as a quantitative definition of ultra-poverty (circle all that apply)?
   a. Daily expenditure of less than $0.62
   b. Daily expenditure of less than $0.50
   c. Calorie consumption of less than 80 percent of daily energy requirements, while spending at least 80 percent of income on food
   d. All of the above

3. List two major differences between poverty in Africa and poverty in the United States.

4. Motor vehicles, education, and water supplies are all examples of ____________.

5. Explain how a poor family that relies on animals for farm labor could fall into a poverty trap.

Christopher Barrett Lecture Summary

The news article below summarizes a university lecture, delivered by Cornell University Professor of Economics Christopher Barrett, on the topic of rural ultra-poverty. Barrett addresses many of the topics covered in this lesson, including spatial and temporal ultra-poverty trends, the role of productive assets in the poverty cycle, and the importance of asset-based agricultural development. As you read the summary, think about how Barrett's descriptions of the ultra-poverty cycle complement and extend those that you have read in other lesson materials. Pay particular attention to the real-world examples that Barrett gives and to his suggestions for antipoverty intervention.

"Breaking the Persistent Cycle of Ultra-Poverty in Rural Africa"

Kate Johnson—Stanford Center on Food Security and the Environment

04 May 2011

"Most of the people in the world are poor, so if we knew the economics of being poor, we would know much of the economics that really matters. Most of the world's poor people earn their living from agriculture, so if we knew the economics of agriculture, we would know much of the economics of being poor."—Theodore W. Schultz, accepting the Nobel Prize in Economics, December 8, 1979

More than thirty years ago, Theodore W. Schultz won the Nobel Prize in Economics for his work on economic development and agriculture in developing countries. Last week, Cornell University Professor Christopher Barrett told Stanford students, faculty, and community members that Schultz's ideas suggest a powerful approach to breaking persistent cycles of poverty in modern rural Africa.

Barrett, a Professor of Applied Economics and Management and an expert in poverty and international development, visited the Stanford campus for a two-hour symposium entitled "Assisting the Escape from Persistent Ultra-Poverty in Rural Africa." He described the economics of poverty and agriculture in rural Africa as a series of downward spirals in environmental and human health. The struggle to survive on insufficient resources, he explained, leads to disease and degradation that result in still deeper poverty. Escaping this cycle requires an influx of assets—a "lump of starting capital" in both private and public goods—that Barrett said the international community can provide.

"It takes money to make money," Barrett said. "Asset holdings, and their productivity through technology and markets, matter enormously."

When African farmers and pastoralists slip below a certain threshold of asset poverty, Barrett explained, they face negative feedbacks that set off a steep decline. For example, a farmer who cultivates the same tiny plot of land year after year depletes soil nutrients to the point where even heavy fertilizer applications cannot revive the crop. Similarly, a pastoral family that begins with a small herd becomes sedentary, unable to provide for the elderly and infirm while keeping their animals on the move. Stuck in one place, the herd exhausts local resources, and animals and humans alike suffer the health consequences of insufficient food and water.

A farmer who begins with plenty of land can sustain higher yields and invest surplus profits in education, health care, better equipment, and still more land. But for the small farmer, incentives to invest in a better future are low, because the consequences of losing even a little income—an accelerated decline toward deeper poverty—are so severe. Subsistence activity takes precedence, and when bad weather or disease strikes, the results are devastating. Limited access to credit, technology, and markets; weak government; and a harsh physical landscape make it still more difficult for rural Africans to invest in productive assets and recover from chance shocks.

These negative feedbacks and perverse incentives, Barrett said, make African poverty uniquely persistent. While poor families in the developed world usually experience brief deprivation as a result of job loss or another isolated event, ultra-poor families in rural Africa have exhausted their land, livestock, and other productive assets. Without the means to restore natural and human capital, they may face a lifetime of poverty. "In the U.S., poverty, while distressingly widespread, is a short-term phenomenon," Barrett noted. "It is qualitatively and ethically different to talk about people who have very little hope of leaving poverty."

But Barrett said that the next generation of rural Africans has reason to hope. While there is no one-size-fits-all approach, targeted investment could improve the outlook for many poor African nations. Barrett cited a generation of successful poverty relief efforts in Asia, where ultra-poverty rates in some countries have fallen from the high teens to less than five percent. "East and Southeast Asia were at least as grim a generation ago as Africa is today," Barrett emphasized. "We know from the historical record that the world can move a lot of people out of poverty very quickly."

Citing Schultz's Nobel Prize acceptance speech, Barrett suggested that the international community focus first on reversing the cycles of decline that have pushed so many African farmers into meager subsistence agriculture. Farm output, he said, universally impacts the rural poor. When output increases, poor farmers gain directly by selling their surplus. The extra supply also keeps local food prices low, benefiting the vast majority of rural Africans who consume more food than they produce.

Barrett described several possible "entry points" to stimulate agricultural productivity, including direct land and livestock grants, organized provision of rural education and health care, and renewed commitment to African crop research. Private entrepreneurs, he said, are particularly well situated to invest in the technology and infrastructure needed to open rural markets, support soil and water conservation, and improve communication between buyers and sellers.

Barrett said that relief efforts should ultimately turn their attention to moving rural Africans out of agriculture. High rural population densities have compressed average farm sizes to a fraction of a hectare, he explained, making farming an unsustainable enterprise. More and more rural Africans are suffering the consequences of trying to do too much with too little.

"They find farming hard work," Barrett said, "and they'd like their kids to be able to find something else to do."

Barrett already sees a brighter future for those farmers and their children. "With governments and private investors already increasing their commitments to agriculture and rural development in Africa," he said, "I firmly believe we are in the early stages of being on the way."

Reading Guide: Christopher Barrett Lecture Summary

1. Carefully reread the quote from Theodore W. Schultz's Nobel Prize acceptance speech. Do you think that his statements are still true today, three decades after later? Why or why not? Which specific points, if any, do you think have changed?

2. What does the phrase "it takes money to make money" mean in this context? Explain in your own words, with a hypothetical example.

3. Barrett says that "Asset holdings, and their **productivity through technology** and markets, matter enormously." How does asset productivity depend on technology and markets? Describe a hypothetical scenario in which a technology or market system could make an asset more productive.

4. Barrett gives two examples of communities that are vulnerable to rural poverty traps. Name these communities, and the main productive asset on which each community relies.

5. According to the summary, why are small African farmers reluctant to invest in productivity-enhancing assets?

6. Why does Barrett believe that small African farmers have "reason to hope" for a better future for their children?

7. What productive assets does Barrett believe that the international community should provide for small farmers in Africa?

8. What does Barrett believe should be the ultimate goal of relief efforts, and why? What do you think will be necessary to achieve this goal?

Answer Key to Handout 1 (Lesson Introduction)

1. Describe the first graph in a few short sentences. What do the axis labels mean (recall Lesson One), and what are the units of each axis? What does each point represent, and what do the different styles of point signify? Where did the data used to construct the graph come from?

   Student descriptions should include the following points:

   - *Axis labels: The poverty headcount ratio (x-axis) refers to the percentage of the population whose consumption expenditures fall below $1.25 per day; the poverty gap (y-axis) refers to the average poor person's percentage distance below the $1.25 per day poverty line.*
   - *Axis units: percentage*
   - *Points: Each point represents one country; the different point styles distinguish between regions (sub-Saharan Africa, Asia, and Latin America).*
   - *Source: The source is listed on the graph as the World Bank; exceptional answers will speculate on data-gathering techniques (e.g., household surveys, consultation with regional governments, etc.).*

2. What trends do you see in the first graph? Do the variables on the axes appear to be correlated? Are the points grouped in any significant way? Summarize the implications of the graph in one or two clear, concise sentences.

   Students should note, at a minimum, that headcount ratio and poverty gap appear to be positively correlated—countries with higher headcount ratios also have larger poverty gaps. Students should also note that the points are clumped by region, with the highest ratios/largest gaps in sub-Saharan Africa, followed by Asia and finally Latin America.

3. Describe the second graph in a few short sentences. What are the measures and units shown on each axis? What do the different lines represent? Where did the data used to construct the graph come from?

   Student descriptions should include the following points:

   - *Axes: The graph plots continuous years in poverty against percent of the population; for example, the point (2, 50) would indicate that 50 percent of the population has lived below the indicated poverty line for two years or more.*
   - *Lines: Each line on the graph represents a country or community; the labels indicate the poverty line used for each country/community.*
   - *Source: The source of the graph, listed below the image, is a paper by Cornell University professor Christopher Barrett. Exceptional answers will recognize that the data probably comes from household-level surveys (including the U.S. census).*

4. What trends do you see in the second graph? Do any differences or similarities between the four plotted lines strike you as important? Do the variables on the axes appear to be correlated? Summarize the implications of the graph in one or two clear, concise sentences.

   Students should recognize all or several of the following:

   - *The U.S. line drops off sharply, while the African lines are close to flat.*
   - *The above observation suggests that the variables are correlated—in communities with higher poverty rates (e.g., the African communities), households spend more years in poverty.*
   - *Poverty rates vary widely even within a single country (central vs. southern Madagascar).*

- *The lines for the United States and Kenya are shorter than those for Madagascar, indicating that communities were tracked for less time (excellent answers will speculate on why this might be the case, contrasting possible reasons in the United States vs. Kenya).*
- *The poverty lines used for African countries are much lower than that used for the United States, and yet rates and durations are still higher.*

5. Summarize the most important implications of both graphs in a single sentence.

   Student summaries should capture these key points:

   - *Where poverty is more prevalent, it is also more extreme (first graph)*
   - *Depth and prevalence of poverty vary across developing region (first graph)*
   - *Where poverty is more prevalent, it tends to last longer (second graph)*
   - *Poverty lasts much longer in Africa than it does in the United States.*

Answer Key to Handout 3 (Assets and Poverty Trends)

Graph #1: Poverty and Motor Vehicle Prevalence

Questions:

1. Describe the graph. What are the values and units on each axis? What does each point represent?
   The graph plots poverty rate (percent of population) against the number of motor vehicles per thousand people. Each point represents one country, and the different point styles indicate different regions (sub-Saharan Africa, Asia, Latin America).

2. Do you see any trends in the graph—correlation of variables, clustering of points, etc.? Describe the trends you see, and summarize their significance (i.e., the key point made by the graph) in a sentence.
   Students should recognize that countries with many motor vehicles tend to have to lowest poverty rates, and that African (and most Asian) countries are clustered in the upper-left corner of the graph (high poverty, few vehicles).

Graph #2: Poverty and Literacy

Questions:

1. Describe the graph. What are the values and units on each axis? What does each point represent?
   The graph plots the poverty rate (percent of population) against the literacy rate (percent of adults). Again, points represent countries; point styles represent regions.

2. Do you see any trends in the graph—correlation of variables, clustering of points, etc.? Describe the trends you see, and summarize their significance (i.e., the key point made by the graph) in a sentence.
   Students should recognize that countries with the highest literacy rates—mostly Asian and Latin American countries—tend to have the lowest poverty rates.

Graph #3: Poverty and Precipitation

Questions:

1. Describe the graph. What are the values and units on each axis? What does each point represent?
   The graph plots poverty rate (percent of population) against annual precipitation depth, in millimeters. Each point represents one country; point styles indicate regions.

2. Do you see any trends in the graph—correlation of variables, clustering of points, etc.? Describe the trends you see, and summarize their significance (i.e., the key point made by the graph) in a sentence.
   Students should recognize that precipitation depth and poverty are loosely correlated, with many low-poverty countries receiving higher precipitation, but that the trend is not so pronounced as those in the previous graphs. Excellent answers will recognize that while precipitation is an important variable in food production (and therefore rural livelihood), it may be less significant if irrigation is widespread

and/or if local farmers have access to drought-tolerant crops. Students may also address these points in response to the first Bonus Question (below).

For discussion:

1. Describe any differences between the trends you saw in the three graphs (e.g., varying degrees of correlation between variables, clustering of points, etc.). How would you explain these differences?
   Evaluate answers based on insight, logic, and creativity. Students may elaborate on the weaker correlation in the precipitation graph, as discussed above. Students may also note differences in regional clustering—for example, most Asia and Africa are more similar in terms of motor vehicle prevalence than in terms of literacy rates.

2. What do the three factors shown in the graphs above—vehicle prevalence, literacy, and precipitation—have in common, beyond any apparent correlation with poverty rates?
   Evaluate answers based on insight, logic, and creativity. While students may not yet know the exact phrase, they should recognize at some level that all three of these factors represent productive assets—their presence can increase regional, household, or individual productivity.

Answer Key to Handout 4
(Assets, Structural Poverty, and the Rural Poverty Cycle)

Answer the following questions on a separate sheet of paper. Each answer should be in the form of one or two well-organized short paragraphs (no more than 150 words in all), written in complete sentences using appropriate vocabulary and correct grammar.

1. Consult an online source for a definition of *institution* (you will find several — choose the appropriate definition for this context). Explain the role of institutions in the poverty trap cycle (i.e., explain how weak institutions lead to poverty and vice versa).

   Students should select one or both of the following relevant definitions:

   - *A custom, practice, relationship, or behavioral pattern that lends structure to a community or society, e.g., the institution of marriage; or*
   - *An organization or foundation, especially one dedicated to performing public services, e.g., government institutions.*

   Students should recognize that strong institutions help people cope with long-term poverty and short-term disasters by strengthening ties between friends, neighbors, and relatives, and by scaffolding functional, appropriate government responses. Weak institutions, by contrast, imply poor links between citizens and their leaders, leaving doors open to social isolation and political unrest.

2. Choose a productive asset (not land) from the examples given in this handout or from your own experience. Explain:

a. Why your choice is a productive asset (refer to the definition above); and

b. How an inadequate stock of this asset could push a household into a poverty cycle.

   Evaluate student answers based on:

   - *selection of an appropriate asset, and defense of the choice with specific reference to the definition given in this handout; and*
   - *logic, creativity, and attention to detail in the explanation of the asset's role in the poverty cycle.*

3. The term *poverty cycle* implies that any of the factors listed in Barrett's slide could initiate a negative feedback loop. Describe a scenario in which another of these factors, such as hunger or resource degradation, could initiate the poverty cycle.
   Evaluate student answers based on logic, creativity, and attention to detail.

Answer Key to Handout 5 (Viewing Guide: Jeff Raikes Video Clip)

1. The project that Raikes describes in this clip centers around a dairy chilling plant. Use the context that Raikes provides to formulate a description of what these plants do and why they are important to small farmers. Write your description below.
   a. What is a dairy chilling plant?

   A dairy chilling plant is a refrigeration facility—its primary function is keeping fresh milk cold to prevent spoilage. Some plants are also equipped for producing processed dairy products such as yogurt and cheese.

   b. Why are these facilities important to small farmers?

   For small dairy farmers, chilling plants offer a means to store milk for an extended period. Storage capacity removes the constraints associated with needing to sell milk quickly, before it spoils, to any buyer at any price. The plant itself may function as a buyer, purchasing milk from farmers, packaging and processing it for sale in the formal market—i.e., to regional or national distributors—in large quantities and at a profitable price.

   Developing-country dairy chilling projects, such as the one that Raikes describes in this talk, often work to organize farmers into cooperatives so that they can invest jointly in dairy chilling equipment and share in the profits from the plant's sales. These projects also work to establish the plant as a community hub that offers other resources, such as veterinary and fertility services for cattle and best-practices education for farmers.

   For more information on the Gates Foundation's work with dairy farmers in Africa, visit www.gatesfoundation.org and look under "Progress Reports" for the Heifer International project "Dairy Development for Farm Households in East Africa."

2. According to Raikes, the chilling plant project involved several different types of investment to assist farmers. List the three general categories that Raikes mentions:

   Science and technology (livestock technology)

   Farm management practices

   Market access

3. Because of the dairy chilling plant, farmers can now receive a ______________________ for milk.
   Predictable price

4. The stability provided by the dairy chilling plant gave farmers an incentive to invest in ________________________.
   Better technology; better dairy cattle

5. Raikes mentions several specific services in addition to dairy chilling that the plan provided for farmers. List those services:
   Artificial insemination; education about feed management for maximizing milk yield

6. In Raikes's experience, when poor farmers are able to increase their income, they almost always invest first in __________________________________.
   Education for their children

Answer Key to Handout 7 (Quiz)

1. Define the following terms:
   a. Ultra-poverty
   A state of especially deep poverty; the "poorest of the poor." May also refer to various quantitative definitions, e.g., less than $0.50 per day, food consumption below 80 percent of energy requirements, etc.
   b. Chronic poverty
   Persistent poverty, enduring for years, decades, or generations; contrast with transitory poverty
   c. Transitory poverty
   Poverty that occurs in short spells (a few months or less)
   d. Structural poverty
   Poverty that results from a fundamental lack of productive assets
   e. Stochastic poverty
   Poverty that results from chance events (unemployment, weather, or health shocks, etc.) in the presence of adequate asset wealth

2. Which of the following has been used as a quantitative definition of ultra-poverty (circle all that apply)?
   a. Daily expenditure of less than $0.62
   b. Daily expenditure of less than $0.50
   c. Calorie consumption of less than 80 percent of daily energy requirements, while spending at least 80 percent of income on food
   d. All of the above

3. List two major differences between poverty in Africa and poverty in the United States.
   Poverty in Africa is more severe (more ultra-poverty) and lasts longer (more chronic poverty).

4. Motor vehicles, education, and water supplies are all examples of ____________.
   Productive assets

5. Explain how a poor family that relies on animals for farm labor could fall into a poverty trap.
   Answers will vary. Students should recognize that a family with few animals may overwork them to the point of weakness, resulting in lower productivity and reduced income. Ultimately, the family may be forced to sell or kill the animals for food. Family members will then be forced to work the farm by hand, but with little food available, they will be unable to endure the hard labor without becoming ill or exhausted. Productivity and income will thus continue to decline.

Answer Key to Handout 9
(Reading Guide: Christopher Barrett Lecture Summary)

1. Carefully reread the quote from Theodore W. Schultz's Nobel Prize acceptance speech. Do you think that his statements are still true today, three decades after later? Why or why not? Which specific points, if any, do you think have changed?
   Students should recognize that Schultz's statements do still hold true to a large extent; as they have learned in this and previous lessons, poverty rates remain above 50 percent in much of sub-Saharan Africa, with the poorest countries being those in which large proportions of the population work in agriculture. However, attentive students will also note that poverty rates have declined dramatically in many developing regions (particularly East Asia) in the last 30 years, so that Schultz's statement that "most of the people in the world are poor" is no longer strictly true.

2. What does the phrase "it takes money to make money" mean in this context? Explain in your own words, with a hypothetical example.
   The statement could be rephrased as "it takes assets to make money" or even "it takes assets to make assets"; essentially, Barrett points out that below a certain level of wealth and stability, income-enhancing investment becomes impossible. For example, a small farmer whose soil is depleted from intensive farming could significantly increase his or her future income by buying just a little additional land—but if the farmer can barely afford daily essentials, he or she will not even consider such an investment.

3. Barrett says that "Asset holdings, and their productivity through technology and markets, matter enormously." How does asset productivity depend on technology and markets? Describe a hypothetical scenario in which a technology or market system could make an asset more productive.
   Technology and infrastructure help certain assets perform to their full productive potential; well-functioning markets allow farmers and other asset-users to trade surplus production for other necessities. For example: A farmer who invests in a second milk cow (a productive asset) will need access to a chilling facility (technology) to store surplus milk, as well as access to a well-functioning market in which to sell the surplus production for a fair price before it spoils.

4. Barrett gives two examples of communities that are vulnerable to rural poverty traps. Name these communities, and the main productive asset on which each community relies.
   Pastoralists: livestock
   Farmers: land

5. According to the summary, why are small African farmers reluctant to invest in productivity-enhancing assets?
   According to the summary, small farmers are reluctant to invest because "the consequences of losing even a little income … are so severe." In other words, farmers whose income barely covers their daily essentials are reluctant to risk even a small sum on an uncertain investment—if, for example, a farmer invests in fertilizer but a bad weather year results in lower rather than higher crop yields despite the investment, he or she will be worse off than before.

6. Why does Barrett believe that small African farmers have "reason to hope" for a better future for their children?
Barrett is encouraged by Asia's rapid progress in poverty reduction over the past 30 years.

7. What productive assets does Barrett believe that the international community should provide for small farmers in Africa?
Barrett suggests investment in five major areas (students should recognize most, if not all, of these suggestions as productive assets mentioned elsewhere in the lesson):
   - *land*
   - *livestock*
   - *education*
   - *health care*
   - *agricultural technology/crop development (e.g., research and education aimed at adapting production practices and crop varieties to rural Africa's physical and social constraints)*

8. What does Barrett believe should be the ultimate goal of relief efforts, and why? What do you think will be necessary to achieve this goal?
According to Barrett, relief efforts should ultimately aim to move rural Africans out of agriculture and into other industries. Agricultural land—a key productive asset in this scenario—is in finite supply in rural Africa, and as the rural population has grown, farm sizes have declined to a point where many farms are too small to provide even a meager living.
Students may have various suggestions as to how to achieve this shift away from agriculture; most students should recognize that education and training, aimed at preparing rural Africans for jobs in other industries, will play a key role.

Lesson Four

Economic Access to Food
Part Three:
Agriculture in the National Economy

Organizing Questions

- How do economists describe economic structure and function at the national (macroeconomic) level?
- What macroeconomic characteristics are most often associated with national food insecurity?
- What role does agriculture play in national economies and in macroeconomic development?
- How well does the theory of macroeconomic development describe the actual development paths of various countries?

Introduction

This lesson introduces a new link between agricultural productivity and food security: Higher agricultural productivity raises rural incomes and reduces the share of the workforce engaged in farming, leading to the growth of new, higher-value industries that increase economic prosperity and reduce poverty at the national level. Students learn common macroeconomic terms used to describe the structure, function, and productivity of national and regional economies; complete data activities that explore the links between macroeconomic variables and food security; and work in groups to complete a case study of national development paths in four countries.

Note: Although this lesson is intended to be accessible to students with minimal economics background, the economic concepts covered are somewhat more advanced than in previous lessons. Instructors should review the materials carefully to ensure that this lesson is appropriate for their students. Subsequent lessons in this unit do not assume familiarity with the material in this lesson.

Objectives

In this lesson, students will

- use macroeconomic vocabulary to describe features of a national economy;
- identify connections between food security and the structure and function of a national economy;
- understand how agricultural production interacts with other economic activities;
- learn how, where, and why agricultural productivity drives macroeconomic development;

- draw logical conclusions from data and graphs; and
- work productively in groups.

Materials

- Handout 1, *Introduction and Key Terms*
- Handout 2, *Key Terms Discussion and Graph Analysis*
- Handout 3, *Agriculture and Economic Development*
- Handout 4, *The Comprehensive Africa Agriculture Development Programme*
- Handout 5, *Reading Guide: The Comprehensive Africa Agriculture Development Programme*
- Handout 6, *Ousmane Badiane Lecture Summary*
- Handout 7, *Reading Guide: Ousmane Badiane Lecture Summary*
- Handout 8, *Country Case Study*
- Handout 9, *Country Case Study Data*
- Handout 10, *Quiz*
- (Optional) Handout 11, *Inequality Data Activity*
- Answer Key, *Introduction and Key Terms*
- Answer Key, *Key Terms Discussion and Graph Analysis*
- Answer Key, *Agriculture and Economic Development*
- Answer Key, *Reading Guide: The Comprehensive Africa Agriculture Development Programme*
- Answer Key, *Reading Guide: Ousmane Badiane News Summary*
- Answer Key, *Country Case Study*
- Answer Key, *Quiz*
- (Optional) Answer Key, *Inequality Data Activity*
- Reference Material: *Ousmane Badiane, "Why has African been slow in developing its agriculture?" Lecture delivered at Stanford University, April 7, 2011*. Lecture available online. Instructors may wish to review this lecture for background on the lesson topic or to direct advanced students to relevant lecture sections. Note that the material in this lecture is at an advanced level.

Equipment

- Internet-ready computers for student research (Day Two)

Teacher Preparation

Prior to teaching the lesson, instructors should:

- Review all handouts, and make the correct number of copies (one per student, unless otherwise indicated). Note that the lesson procedures outline options for dividing Handouts 4–7 (the two reading assignments) among the class or assigning these readings as optional. Decide on a strategy for assigning these readings, and adjust the number of copies as appropriate.

- Arrange the room for group work throughout the lesson. Note: Students will work in groups of 3 or 4 throughout the lesson; the instructor may wish to form these groups prior to Day One.
- If possible, prior to Day Two, arrange for student access to Internet-ready computers.
- If Internet-ready computers will not be available on the day of the case study, visit one of more of the Web pages listed in the case study instructions, and print information on each of the four countries for students to use as background in their case study report. Make the correct number of copies.
- Review Handout 10, *Inequality Data Activity*, and determine whether it is appropriate for the class. Make copies of the activity as required.
- Optional: Instructors may wish to watch Ousmane Badiane's lecture (available online) in its entirety for additional information on the topic. If desired, select clips from the lecture to show to advanced students.

Time

The complete lesson requires at least three 50-minute class periods. Students also complete a homework assignment prior to Day One. Suggestions for extending or shortening the lesson are provided in the *Extensions and Excerpts* section, below.

Procedures Before Day One

Explain to students that, during the next two class periods, they will explore the interactions between food security, food production, and national economic development. They will begin by learning terms used to describe economic productivity and structure at the national, or macroeconomic, level. Ask students if they can think of any terms or concepts from previous lessons that describe economic or social features at a national level — students may mention poverty rate and malnutrition prevalence (Lesson One) or employment share in agriculture and average household expenditure on food (Lesson Three, Part One). Distribute one copy of Handout 1, *Introduction and Key Terms* to each student, and ask students to read the handout and complete the exercises for homework.

Day One

1. (15 minutes) Divide the class into groups of 3 or 4 students. Distribute one copy of Handout 2, *Key Terms Discussion and Graph Analysis* to each group. Ask students to work in their groups to complete Handout 2, referring to Handout 1 as necessary for explanations of key terms. The instructor should circulate among the groups as students work to answer questions and clarify important concepts.
2. (25 minutes) When most groups have finished work on Handout 2, distribute one copy of Handout 3 to each student. Ask students to complete the exercise (the first part of the handout) in groups. If groups finish early, they may go on to read the explanation and discuss what they observed.

3. (10 minutes) Lead a class discussion to draw out the key ideas from the exercise. Ask students to describe what they observed in the graph (briefly summarizing their responses to questions 1–4 in the exercise) and to respond to the following additional questions:
   a. Why is low agricultural output per worker correlated with high employment in agriculture? What condition are countries trying to meet through a combination of efficiency and labor? (Answer: sufficient food production to provide for their populations.)
   b. What are the disadvantages of having most of the workforce engaged in agriculture?
   c. What conditions must countries meet (with respect to agricultural production) before their economies can diversify into the secondary and tertiary sectors, and how can countries achieve this goal?
   d. Conclude by discussing the final question below the explanation on Handout 3.
4. At the end of the period, distribute one copy each of Handout 4, *The Comprehensive Africa Agriculture Development Programme*; Handout 5, *Reading Guide: The Comprehensive Africa Agriculture Development Programme*; Handout 6, *Ousmane Badiane Lecture Summary*; and Handout 7, *Reading Guide: Ousmane Badiane Lecture Summary,* to each student. Ask students to complete the readings for homework.

Note: Instructors may choose to assign one or both of the readings or reading guides as optional; instructors may also choose to assign half the class to each reading, and group students for discussion on Day Two such that both readings are represented. Each student should receive one copy of all four handouts, for reference, even if the instructor chooses to reduce the assignment.

Note: Instructors with advanced students may assign the Optional Data Activity as homework in addition to the two readings (see the *Extensions and Excerpts* section for details on assigning the optional activity).

Day Two

1. (15 minutes) Ask students to reassemble in their groups from Day One and to discuss the readings that they completed for homework; students should compare answers to the reading guide questions, and take notes (on the appropriate reading guide) on their classmates' reports on the reading that they did not complete, if applicable. While students are working, distribute one copy each of Handouts 8 and 9, *Country Case Study* and *Country Case Study Data,* to each student. Note that although each group will work on only one country for the case study, students should receive the entire dataset for reference.
2. (5 minutes) Bring the class back together, and assign each group to one of the four countries for the case study (depending on the number of students, several groups may be assigned to the same country; try to assign a roughly equal number of groups to each country).
3. (30 minutes) Give students the remainder of the period to work on the case study. Encourage students to divide the tasks among group

members, and to make a plan for completing the case study outside of class (before the next class period). Inform students that they will have a few minutes to meet in their groups before presenting their conclusions during the next class period. If possible, make Internet-ready computers available for student research.

4. At the end of the period, inform students that they will have a short quiz at the beginning of the next class period. Students may wish to review Handouts 1–3 in preparation for the quiz. Students should also refine their work on these and all other assigned handouts; all work in the lesson will be collected at the end of the next class period.

Day Three

1. (10 minutes) Distribute one copy of Handout 10, *Quiz,* to each student. Give students about 10 minutes to work on the quiz, and then collect quizzes for evaluation.
2. (10 minutes) Ask students to reassemble in their groups. Give students about 10 minutes to discuss the results of their case study research and prepare a brief (two minute) presentation highlighting their conclusions for their classmates. Students should also use this time to exchange information as necessary so that all members can complete the case study handout.
3. (30 minutes) Bring the class back together, and call the groups forward one at a time to present, allowing about two minutes per presentation. Suggestion: Group presentations by country, and after all groups have presented for one country, spend a few minutes as a class discussing the similarities and differences between the presentations and conclusions.
4. At the end of the period, collect Handouts 1–3, Handouts 5 and 7 (if assigned), and Handout 8. Be sure that students attach any additional sheets with notes or answers when handing in their work.

Extensions and Excerpts

Extensions: The materials for this lesson include an optional data activity, which focuses on economic measures of inequality and the links between inequality and poverty. The activity has two parts: a data exploration, in which students answer questions about a graph given in the activity handout, and a data manipulation, in which students construct their own measures and graphs from a data table. Instructors who wish to introduce students to quantitative measures of income inequality, and the effects of income inequality on food security in various regions, should have students complete at least Part One of the Optional Activity. Instructors who wish to extend these concepts, or who wish to give students additional practice with data manipulation and analysis, should also have students complete Part Two. Part Two includes data for three global regions (Africa, Asia, and Latin America); instructors may choose to break the class into groups, with each group focusing on one region, and to conclude the activity by discussing the Part Two questions (which draw comparisons between the regions) as a class.

Excerpts: Instructors with less time to devote can omit the in-class case study, concluding the lesson at the end of Day One or with administration of the Quiz and a brief discussion of the Day One homework at the beginning of Day Two. Instructors may also choose to assign only the graph analysis portion of the case study, and to ask students to complete this exercise in class on Day Two.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess the student's work on Handout 1, *Introduction and Key Terms,* based on accuracy of the student's responses (use the Answer Key as a guide).
- Assess the student's work on Handout 2, *Key Terms Discussion and Graph Analysis,* based on
  - o the extent to which the student's responses to question 1 reflect an understanding of the definitions of GDP and GNI (use the Answer Key to Handout 2, and Handout 1, as guides);
  - o accuracy of the student's responses to the graph analysis questions (question 2; use the answer key as a guide);
  - o the extent to which the student's explanations of the trends in the graph (question 2) reflect an understanding of the content of Handout 1 (use the answer key as a guide); and
  - o the level of detail, creativity, and logical insight in the student's responses (questions 1 and 2).
- Assess student work on Handout 3, *Agriculture and Economic Development,* based on
  - o accuracy of the student's responses (use the answer key as a guide);
  - o the level of detail, creativity, and logical insight in the student's explanations of the trends in the graph (especially questions [b] and [d]);
  - o the student's demonstrated ability to employ appropriate vocabulary and to connect the exercise to material presented elsewhere in the lesson and unit (especially question [e]); and
  - o the quality of the student's contributions to the final group or class discussion.
- Assess student work on Handout 4, *Reading Guide: The Comprehensive Africa Agriculture Development Programme,* based on
  - o accuracy of the student's responses (use the answer key as a guide);
  - o the student's demonstrated ability to connect the reading to the content of the lesson and to previous lessons in the unit (especially questions 4, 6, and 10); and
  - o the level of detail, creativity, and logical insight in the student's reflections and responses to open ended questions (especially questions 2, 3, and 9).
- Assess student work on Handout 5, *Reading Guide: Ousmane Badiane*

News Summary, based on
  - o accuracy of the student's responses (use the answer key as a guide);
  - o the student's demonstrated ability to draw logical inferences from the material in the article (especially questions 1 and 5); and
  - o the student's demonstrated ability to connect the reading to the content of the lesson (especially questions 2 and 3).
- Assess student work on the *Country Case Study* based on
  - o accuracy of the student's responses to the graph analysis questions (use the answer key as a guide);
  - o the extent to which the student's explanations demonstrate an understanding of the practical significance of the measures shown on the graph;
  - o the student's research effort, as reflected in the level of detail in the student's analysis of the country's economic profile;
  - o the student's demonstrated ability to connect the case study to the lesson content, including correct application of appropriate vocabulary; and
  - o the quality of the student's contributions to the final discussion.
- (Optional) Assess student work on Handout 11, *Inequality Data Activity*, based on
  - o accuracy of the student's responses to the graph analysis questions in Part One (use the answer key as a guide);
  - o the extent to which the student's explanations in Part One (questions 2 and 3) and Part Two (question 2) reflect accurate understanding of the poverty and inequality concepts covered in the handout; and
  - o accuracy of the student's calculations, graphs, and graph analysis in Part Two (use the answer key as a guide).
- Assess students' participation in group work and class discussion throughout the lesson based on
  - o accuracy and appropriateness of contributions;
  - o clear and succinct statement of comments, questions, and answers;
  - o attention to other students' questions and ideas;
  - o ability to follow and promote lively, productive discussion;
  - o open-mindedness and respect for other students' backgrounds and opinions;
  - o willingness and ability to incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
  - o willingness and ability to express confusion and request clarification from other students and the instructor.

Introduction and Key Terms

In the third part of Lesson Four, you will learn explore the connections between agriculture, food security, and economic development at the national level. The branch of economics devoted to studying the behavior of entire national economies is called macroeconomics — in contrast to microeconomics, which focuses on analyzing the choices and responses of individuals, businesses, and households. Macroeconomists are interested in broad indicators such as unemployment and national poverty; microeconomists are more interested in indicators such as the price of a single product, which reflects business and household supply and demand (see Part One of Lesson Four).

Previous lessons in this unit have incorporated elements of both macro and microeconomics. This lesson explicitly introduces terms that macroeconomists use to describe characteristics of a national economy, such as its structure and productivity. You will use these terms often as you investigate the process of macroeconomic development and its relationships to food security and agriculture.

Begin by studying the two definitions below. These terms will appear often in readings and discussions throughout this unit. Check your understanding by completing the exercise below each definition.

Sector (Primary/Secondary/Tertiary)

sector–a broad category of economic activity

primary sector–economic activities that involve extraction of primary, unprocessed natural resources for direct sale or consumption

secondary sector–economic activities that involve processing the outputs of the primary sectors into higher-value products

tertiary sector–economic activities that use a range of outputs from the primary and secondary sectors to offer services or produce intangible goods such as education and hospitality

Economists classify economic activity — the production of goods and services — into different categories called sectors. For example, the agricultural sector encompasses all economic activity related to the production of food and other agricultural products; the textile sector encompasses all activity related to the production of clothing and fabric; etc.

Some sector definitions categorize economic activities more broadly, based on their level of sophistication. Activities in the primary sector, such as agriculture and mining, involve extraction of primary, unprocessed natural resources for direct sale or consumption. The secondary sector includes activities that process the outputs of the primary sectors into higher–value products, e.g., a furniture company uses wood (a product of the primary sector) to build tables and chairs. The secondary sector is also sometimes referred to as the *industrial sector* or the *manufacturing sector.* Finally, workers in the tertiary sector, or *service sector,* use a range of outputs from the primary and secondary sectors to offer services or produce *intangible* (non–physical) goods. For example, a hotel business might use buildings, furniture, processed food, and other primary and manufactured products to produce a good called "hospitality."

The secondary and tertiary sectors are engaged in activities that *add value* to the products of the primary sector, in the sense that a table may be sold for a higher price than the raw lumber used to make it. Thus, the products produced by these sectors are sometimes referred to as *higher-value* products. Higher value products exist within sectors, as well — for example, agricultural products that require specialized care or conditions to grow may sell for a higher price than widely grown staple crops.

industry–a specific group of businesses or activities within a sector; e.g., the agricultural industry, the clothing industry, etc.

Note: The term industry is often used to designate a specific group of businesses within a sector. For example, the agricultural industry is a subset of businesses in the primary sector; the clothing industry is a subset of businesses within the secondary sector. Be careful not to confuse references to a particular industry (subset of a sector) with references to the *industrial* (secondary) sector.

Classify the following productive activities as belonging to the primary, secondary, or tertiary sector of an economy:

1. Family employees sewing clothes as a part of a small home business
2. Factory workers canning produce
3. Miners extracting iron ore
4. A teacher instructing primary students
5. Field workers harvesting crops
6. A bank employee assisting customers with accounts
7. A tour guide teaching visitors about an area's wildlife
8. Construction workers building a new home

Gross Domestic Product (GDP) and Gross National Income (GNI)

At the household level, we use monetary measures of income and consumption to build a picture of overall economic well-being. We can do the same at the national level with two related measures: Gross Domestic Product (GDP) and Gross National Income (GNI).

Gross Domestic Product (GDP)–the total value of all final goods and services produced within a country in a given year

Gross National Income (GNI)–the total income earned by a country's citizen's in a given year, including income earned by citizens working abroad in other countries

GNI is equal to the total income earned by all the country's citizens in a given year — including income earned by citizens working abroad in other countries. GDP is equal to the value (usually expressed in dollars) of all final goods and services produced within a country in a given year, calculated by adding up the amount of money spent on goods and services produced in the country in a given year. Note the following subtleties in the definition of GDP:

- GDP includes only *final* goods and services — not intermediary inputs. For example, if a lumber mill sells plywood to a furniture manufacturer, who builds a table for a private consumer to use in his or her home, national GDP would include only the sale price of the table, not the sale price of the lumber. We assume that the value of the table incorporates the value of the lumber.
- GDP includes only goods and services produced *within* a country. Although we may use consumer spending to estimate GDP, any

estimate based on consumer prices should exclude expenditures on final goods and services obtained in foreign trade. For example, the value of a car manufactured in Japan and sold in the United States is not included in U.S. GDP. However, if a U.S. manufacturer uses steel imported from China to assemble a car in the United States, the final value of the car is included in the U.S. GDP.

We will sometimes find it convenient to refer to the *share* of GDP generated by different sectors of an economy. For example, the *agricultural share* of GDP would be the percentage of the country's total GDP that comes from the production of agricultural products.

per capita GDP/GNI– the average output produced/income earned per person in a given country in a given year, i.e. total GDP/GNI divided by the country's population

Additionally, we can divide total GDP or total GNI by a country's population to obtain an approximation of the value of output or income per worker, or per capita GDP (GNI). These measures may be used as rough estimates of household income and consumption — the same measures that we use as indicators of poverty. We may also refer to per capita GDP within a particular industry or sector, e.g., the *per capita agricultural* GDP would be the average output produced by each agricultural worker.

Indicate whether the following goods and services would be included in the U.S. GDP:

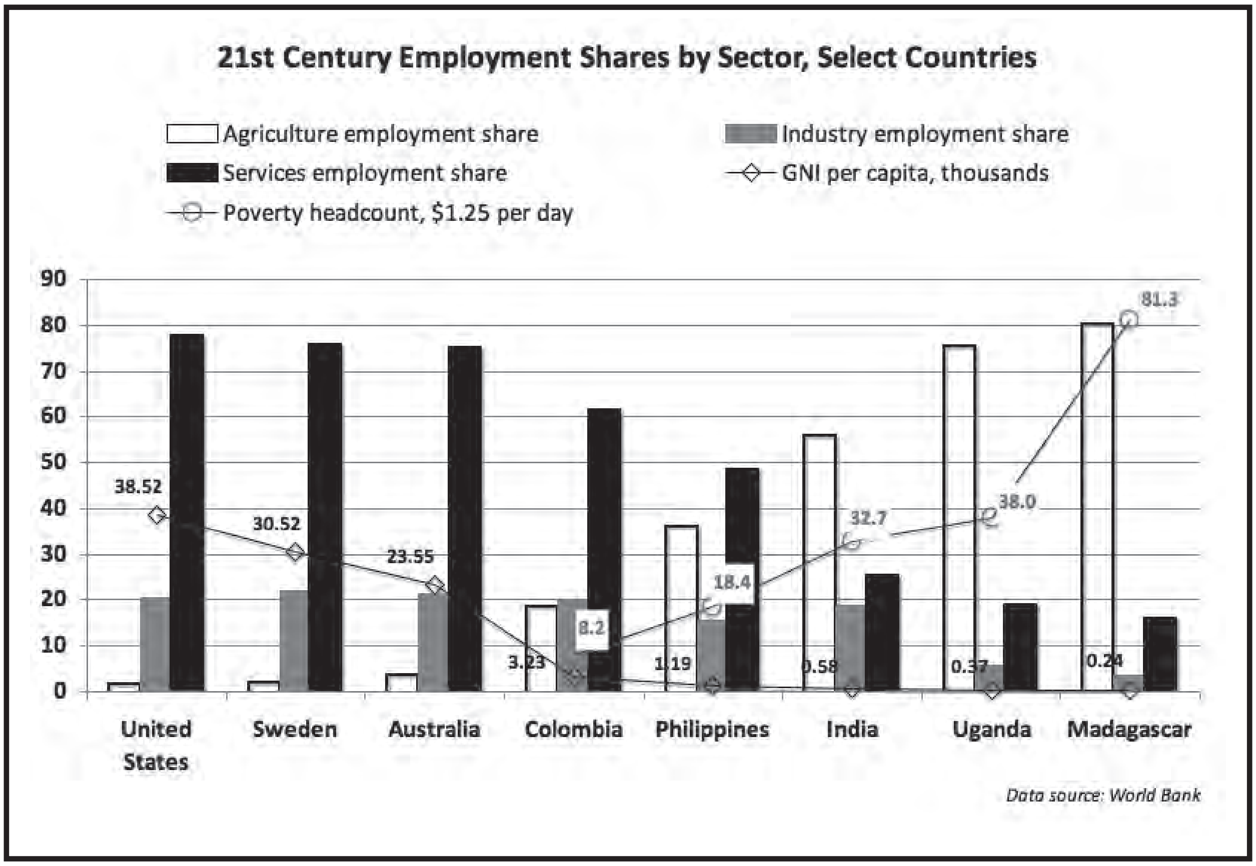
1. A meal served in a U.S. restaurant
2. Tutoring services provided by a private company in a large U.S. city
3. Berries picked by a farmer in California, who then sells them to a local canning company that makes and sells jam
4. A computer manufactured in Japan and sold in the United States
5. A shirt made by a U.S. company using fabric woven in South America
6. Flour milled in the U.S. Midwest and purchased by a home baker, who uses it to make muffins to give to her neighbors

Key Terms Discussion and Graph Analysis

Discuss the following questions with your group. Take careful notes on the discussion, using a separate sheet or the back of this sheet if you need additional space.

1. Do you think GDP and GNI are good overall measures of a country's productivity? What goods or services might be overlooked in these measures? Are there other reasons that GDP and GNI might overestimate or underestimate the value of a country's output?

2. The graph below shows sector employment shares, GNI per capita, and poverty headcount ratios for several different countries.
   a. Describe and explain any apparent relationship between employment in services and GNI per capita in these countries (refer to Handout 1 to inform your explanation).
   b. Describe and explain any apparent relationship between employment in agriculture and poverty rate in these countries. Have you seen this relationship before? (Hint: Think back to Part 1 of Lesson Four).
   c. Describe any apparent relationship between GNI per capita and poverty rate in these countries.



Agriculture and Economic Development

Exercise
Work in your group to answer the following questions. Take careful notes on your group's discussion and responses, using a separate sheet if you need additional space.

The graph below shows national average output per worker (GDP per capita), output per worker in the agricultural sector (the value of output produced by each agricultural worker), and employment share in agriculture for several countries.

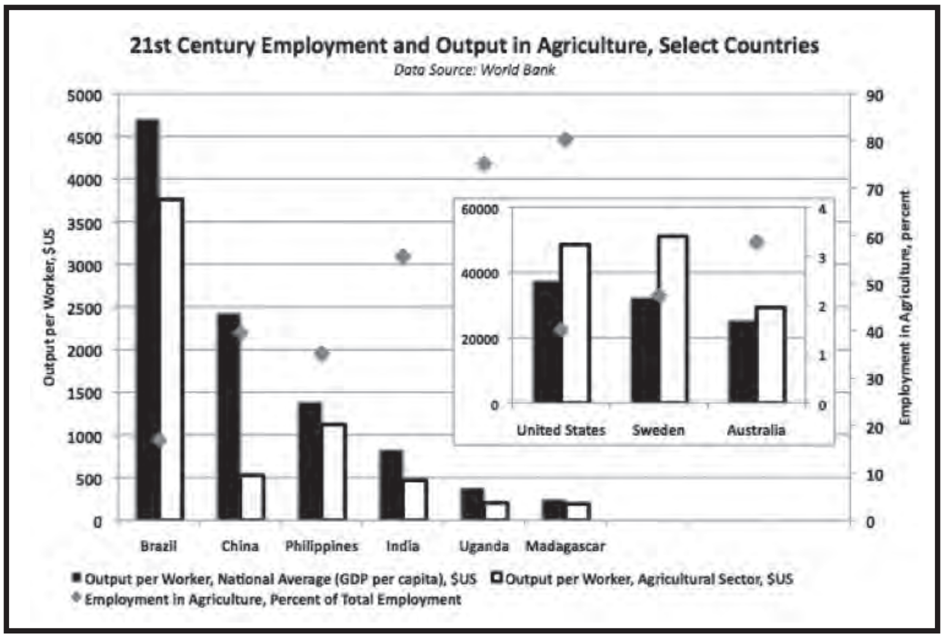
1. Why was it necessary to show the developed economies (U.S., Sweden, and Australia) in a separate graph? Describe the major differences between developed and developing economies, as indicated by the data in this graph.

2. Describe the apparent relationship between employment in agriculture and output per worker in agriculture. What does this relationship indicate about each country's total agricultural output?

3. Describe the apparent relationship between average GDP per capita and agricultural output per worker.

4. Describe any exceptions to the relationships you observed in questions 2 and 3. What might account for these exceptions?

5. How do you think that the process of agricultural production differs between Madagascar and the United States? Think about the type of crops grown, equipment and inputs used, scale of production, etc. Be sure to explain how the data in the graph shaped or supports your conclusions.

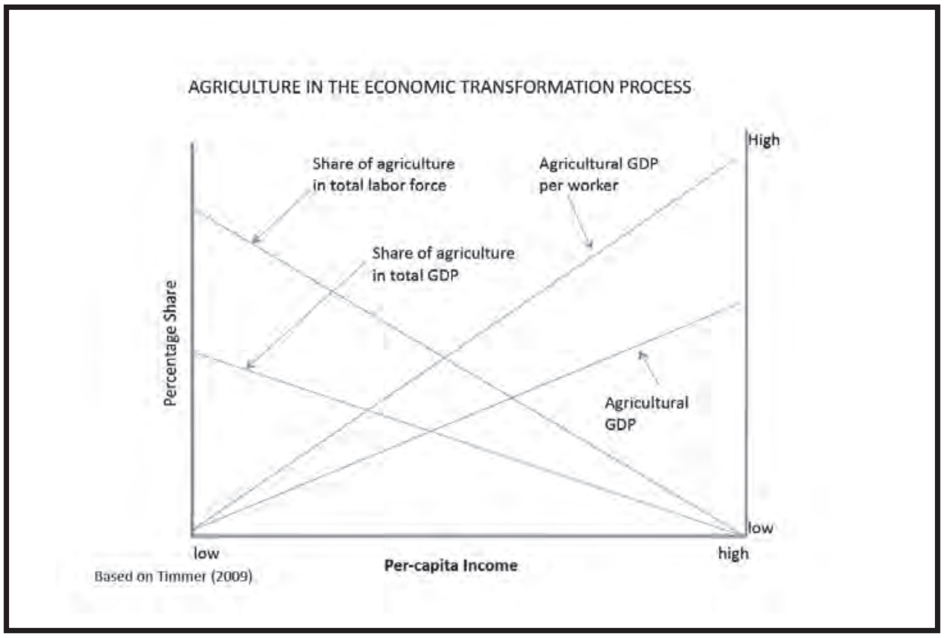


Explanation
Because food is a basic human need, all economies must have some means of producing or providing food. In poor countries that struggle to meet this basic requirement, the economy will do little else — nearly all workers will be employed at some level in the food production industry. For the economy to develop and expand into higher value secondary and tertiary industries, the efficiency of agricultural production must increase so that a single agricultural worker can produce enough food for many people. Think of the national economy as a household: If one household member grows food for everyone, other members can attend school or pursue other jobs away from the farm. Similarly, if a few farmers can feed the entire nation, most citizens can leave agriculture to contribute to development in secondary and tertiary sectors.

Additionally, for economic activity in the secondary and tertiary sectors to be sustainable, agricultural workers must earn enough income to support manufacturing and service businesses. When this condition is met, the result is a consistent flow of income between the sectors — urban industrial and service workers buy food from rural farmers, and rural farmers in turn buy machinery, household products, education, health care, etc., from the urban labor force. If farm profits are too low (as a result of either low food prices or high production costs), there will be no market for urban products, particularly in the early stages of development, when most of the population is still employed in agriculture.

The graph below summarizes the process by which development occurs through increasing agricultural production efficiency. Note that we would expect to observe the following changes as a country's economy becomes more highly developed:

1. Per capita income increases (horizontal axis; per capita income is used here as a proxy for "development")
2. The output produced by each agricultural worker increases, as agricultural production becomes more efficient
3. The share of agriculture in the total labor force declines, as workers leave agriculture for other sectors
4. The share of agriculture in total national output (GDP) declines, as other sectors grow and develop
5. The total output from the agricultural sector increases; in other words, the increase in production efficiency is greater than the decrease in the agricultural labor force. The increase in total food production suggests, as we would expect, that living standards should improve as per capita income increases.



Many factors govern agricultural production efficiency, and many different changes or interventions may trigger an increase in efficiency and an acceleration of macroeconomic development. In the remainder of this lesson, you will explore development paths followed by several different countries over the past three decades. Keep the general theory outlined above in mind as you study each case, and consider how these principles apply — or do not apply — for a particular economy.

Begin by discussing the following question:
Can a poor country increase in wealth without improving the efficiency of agricultural production? Why, or why not? Be sure to discuss arguments on both sides. Consider:

- other resources or productivity improvements that could accelerate macroeconomic development;
- how the historical period in which development takes place (e.g., 19th century vs. 21st century) might affect the development process and the importance of agricultural production efficiency; and
- the long term consequences of "skipping" the agricultural phase of economic development.

Do you know of any examples of countries that developed from an agricultural base, i.e., that began as agricultural economies and expanded rapidly when food production efficiency increased? Explain.

The Comprehensive Africa Agriculture Development Programme

Excerpted with permission from the International Food Policy Research Institute. Source: IFPRI Forum Newsletter. 2008. The 10 percent that could change Africa. October. Washington, DC. This paper can be found at: http://www.ifpri.org/publication/ifpri-forum-10-percent-could-change-africa.

the recent global food price crisis–refers to food price spikes during the year 2008. For example, between July 2007 and July 2008, the international price of corn price jumped from $7.80 to $13.80 per bushel — an increase of more than 75 percent. Similar price spikes occurred in other staple grains, such as wheat and rice

Although the recent global food price crisis has put a renewed spotlight on agriculture, African heads of state placed it on their agendas several years ago. Spurred on by a drought emergency in the early part of the decade, they met in Maputo, Mozambique, in 2003 and pledged to allocate 10 percent of their budgets to agriculture by 2008. That 10 percent commitment was designed to put African countries on track to reach the first Millennium Development Goal of cutting poverty and hunger in half by 2015.

The leaders also threw their political weight behind the Comprehensive Africa Agriculture Development Programme (CAADP), an African-led initiative established in 2002 by the New Partnership for Africa's Development (NEPAD) and the African Union (AU).[1] CAADP's main goal is to focus on agriculture-based development to end hunger, reduce poverty and food insecurity, and increase opportunities in the export market.

paradigm shift–a dramatic change in practice or perspective

IFPRI–the International Food Policy Research Institute (www.ifpri.org)

The Maputo declaration and the broader CAADP agenda marked a paradigm shift in Africa's approach to agriculture. IFPRI's Director for Africa, Ousmane Badiane, says CAADP as an agenda is significant in two ways. First, it recognizes agriculture as the centerpiece of growth and poverty-reduction strategies, and second, as an African-led initiative, it reflects NEPAD's core principles of looking inward for solutions and focusing on responsibility and accountability. "The decision of the African leaders was that Africans are the ones who should first be putting their money in agriculture," says Badiane.

For the 65 percent of Africans who depend on agriculture for a living, these were crucial steps. During the past two decades, agriculture had largely fallen off the map. National governments and donors alike focused their attention on macroeconomic and structural-adjustment policies and allocated resources to education and health instead of agriculture. Despite the fact that agriculture contributes an estimated 30 to 40 percent to GDP, public investment in the sector fell from 6.4 percent in 1980 to 4.5 percent in 2002. Donor interest in agriculture has also fallen steadily since the 1980s. While overall assistance to Africa has risen, most of it has gone to emergency humanitarian aid; only 4 percent of annual development assistance is currently devoted to agricultural investments, compared to 26 percent in the late 1980s.

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1 For more information: http://www.nepad-caadp.net (CAADP); http://www.nepad.org/ (NEPAD); http://www.nepad.org (AU)

agrarian–rural, agricultural; in this case, refers to Africa's extensive land resource and the fact that most of the population is employed in agriculture

As a consequence of this neglect, the agricultural sector is extremely underfunded, and is lagging far behind its Asian and Latin American counterparts in areas such as irrigation, fertilizer usage, and advanced seed technology. Despite its agrarian nature, Africa spends billions of dollars each year importing food, including 45 percent of its rice and 85 percent of its wheat.

According to Cris Muyunda, senior agricultural advisor for the COMESA (Common Market for Eastern and Southern Africa) Secretariat, the biggest result of this negligence was that it increased African vulnerability to drought, hunger, and malnutrition — despite the continent's large land and water resources. "Since the 1960s, every time there has been a small drought, large numbers of people have fallen into massive hunger and have not been able to feed themselves," he says.

For many African countries, increasing agricultural spending to 10 percent of their national budgets in just five years was ambitious. However, it was determined to be the minimum needed to meet poverty-reduction goals. According to Shenggen Fan, director of IFPRI's Development Strategy and Governance Division, India and China spent about 10 percent during the Green Revolution, which helped their countries to significantly increase food production in the 1960s and 1970s.

Reading Guide: The Comprehensive Africa Agriculture Development Programme

1. What prompted African leaders to put agriculture on their agendas in 2003?

2. How much money did African governments pledge to allocate to agricultural development? Does this seem like a large amount of funding to you? Why, or why not?

3. Explain how agriculture based development could "increase opportunities in the export market."

4. The CAADP aims to both "end hunger" and to "reduce…food insecurity." Explain the difference between hunger and food insecurity (Lesson One).

5. Explain, in your own words, why Dr. Ousmane Badiane believes the CAADP agenda is significant.

6. Drawing on previous handouts and material in this lesson, explain why agriculture can or should be "the centerpiece of growth and poverty-reduction strategies."

7. List two statistics from the article that support this statement: "Agriculture is an important part of the African economy."

8. List two statistics from the article that support this statement: “Funding for agricultural development in Africa declined between 1980 and the beginning of the 21st century.”

9. In what areas did African leaders focus public spending between 1980 and 2000? Do you think that they made the right decision? Why, or why not?

10. Explain what the article means by “advanced seed technology” (Lesson Two).

11. What countries does Africa look to as examples in setting and achieving agricultural development and poverty-reduction goals? Why?

Ousmane Badiane Lecture Summary

The following news article summarizes a talk by Dr. Ousmane Badiane, a food policy scholar with the International Food Policy Research Institute, on the topic of agriculture and macroeconomic development. As you read the summary, focus on the connections between Badiane's ideas and the material presented in this lesson. Use the questions in the Reading Guide to evaluate and reinforce your understanding of the key points.

Note that when Badiane discusses industrial *development and businesses, he is referring to development of the secondary sector of the economy.*

April 18, 2011 — *FSI Stanford, FSE News*

Despite 15 years of economic growth, African agriculture still lagging

By Kate Johnson

A poor African farmer produces a little more corn than last year. He sells the surplus in a nearby urban market, and uses the money to purchase a shirt stitched by a local seamstress. With the bumper crop of corn, more and more farmers are interested in the seamstress' wares. The extra income allows her to buy better materials and a new sewing machine. Her business grows, and she begins to sell her work in bigger markets, further from her small village.

Years later, a poor farmer responds to an announcement for a job in a local clothing factory. The monthly wage is more than he currently makes in a year.

This is the vision that Dr. Ousmane Badiane, Africa Director for the International Food Policy Research Institute, presented to an audience of Stanford students and faculty on April 7. In a two-hour symposium entitled "Why has Africa Been Slow in Developing Its Agriculture?" Badiane outlined the steps he believes African nations must take to sustain economic growth and encourage high-value industrial development. Public investment in agriculture formed the backbone of his proposal.

Badiane said that although African nations have experienced unprecedented economic growth in the last 15 years, they still lag behind the developed world in economic sophistication. When workers leave agriculture for other sectors, he explained, the transition usually signifies economic progress.

But in Africa, too many farmers have abandoned their fields to peddle trinkets on the streets as part of a low-productivity service sector. They have left behind an underdeveloped and understaffed agricultural industry.

"Agriculture has just plummeted too fast and too quickly in these countries," Badiane said. "Agriculture is not claiming the share of GDP and employment that it should."

When agriculture thrives, Badiane explained, economies grow and diversify. A wealthier rural population purchases products manufactured by urban entrepreneurs. Productive local farms buffer fluctuations in global crop output and food prices, improving security for urban industrial workers and reducing wage pressure on industrial employers.

"What agriculture needs is what industry needs," Badiane said, emphasizing that investment in one need not mean neglect of the other. “There are a lot of things you can do right by all the sectors at the same time.”

In fact, according to Badiane, every $100 increase in agricultural output could result in up to a $130 increase in output from industry.

Badiane described one step that African governments have already taken to set the positive agriculture-industry feedback in motion. The Comprehensive Africa Agriculture Development Programme is a cooperative effort by the African Union’s 53 member nations to achieve ambitious goals for economic development and investment in agriculture by 2015.

Badiane commended the program’s unprecedented commitment to agricultural growth and its high standards for accountability, policy research, and performance review. He also praised the political momentum and unity that the initiative has generated within Africa, and the respect that it has earned in the international community.

However, Badiane admitted that agricultural growth in Africa cannot always proceed in harmony with other objectives. The need to finance agricultural research and development will put pressure on budgets for broader public welfare programs that Dr. Joel Samoff, a Stanford professor of African Studies, says most African nations simply cannot afford to defund.

“Most countries in Africa spend around $10 per person per year on health,” says Samoff. “How do you reduce that?”

But Badiane suggested that governments may be able to address both agriculture and welfare simultaneously.

They will have to see how they can use social service budgets to sustain growth in agriculture,” he said. “Look at health and education not as an entitlement but as a tool to raise labor productivity.”

Addressing the audience during a question-and-answer session following Badiane’s talk, Harvard Development Professor, Emeritus, Peter Timmer drew attention to the scope of Badiane’s objectives.

“You’re talking about getting industry moving at the same time as you’re getting agriculture moving,” he noted, “and this is a very ambitious undertaking.”

However, Timmer also indicated that he saw the seeds of success in Badiane’s ideas. “I think we’ve just heard a quite profound analysis of Africa’s agricultural problems and its structural history,” he said. “And a possible way forward.”

Reading Guide, Ousmane Badiane Lecture Summary

1. Badiane feels that despite over a decade of rapid economic growth, African nations still "lag behind the developed world in economic sophistication." Explain what *economic sophistication* might mean in this context. In your explanation, contrast economic sophistication with economic productivity (total GDP).

2. What sector of the African economy does Badiane think has grown too quickly? Can you find evidence for this claim? (Hint: Refer to the graph in Handout 2).

3. Describe two ways that a strong agricultural industry can support industrial development.

4. What other objectives might compete with agricultural development for government financing?

5. How does Badiane suggest that African governments approach the competition for public funds? Explain how this approach might affect a new national health-care policy.

(For discussion or extra credit):
Why do you think that the author of the article began with the story of the seamstress and the farmer? Do you think the story is effective? Explain.

What would you change about this news summary? What questions would you have for the author or the speakers that the summary leaves unanswered? Explain.

Country Case Study

In this activity, you will work in small groups to examine macroeconomic structure and development in a particular country. You will use World Bank data (the chart provided by your teacher) and your own research to evaluate the contributions that different sectors and industries made to your country's economic development between 1980 and 2010. The exercise is intended to give you a better understanding of the role that agriculture plays in the economies of various countries, and of the changes that take place in a country's economy as agricultural production efficiency improves. You will also have an opportunity to apply the macroeconomic vocabulary and concepts that you have learned in this lesson.

You may divide the case study tasks as your group deems appropriate, but you must collaborate and share information such that each group member can complete their own copy of the handout. Be sure to document all sources used in Internet research. When you have completed the case study, you will make a short presentation to the class describing your group's work and conclusions. You should prepare to deliver a detailed response to the final discussion question as a part of this presentation.

Use the graph provided for your country to answer the following questions:

1. Did the labor efficiency of agricultural production increase in this country between 1980 and 2010? How can you tell?
2. Did economic activity in industries other than agriculture increase in this country between 1980 and 2010? How can you tell?
3. Describe how per capita incomes changed in this country between 1980 and 2010.
4. Compare the changes in average per capita income to the changes in GDP per worker in agriculture (i.e., income per capita in agriculture). Did one increase more quickly than the other? Is one significantly higher than the other?
5. Based on (a) the percentage of your country's workforce employed in agriculture, and (b) your country's per capita GDP, approximate your country's 21st-century poverty rate. (Hint: Refer to Handout 2, and compare your country's employment share and GDP per capita to those of the countries shown in the Handout 2 graph).

   a.

   b.
6. *Challenge question*: in some countries, the share of agriculture in employment is higher than the share of agriculture in GDP; in others, the GDP share is higher than the employment share. Which is more desirable from a production efficiency and development perspective? What does it mean for the two shares to be exactly equal?

Research your country's history and economy, beginning with the following Web pages:

- The World Bank's "Countries" page: www.worldbank.org;
- The U.S. State Department's country background notes: http://www.state.gov/misc/list/index.htm
- The U.S. Central Intelligence Agency World Factbook: https://www.cia.gov/library/publications/the-world-factbook/index.html

Much of the information on these pages is detailed and technical. Skim the pages for information relevant to this lesson, focusing on answering the following questions:

1. Would you say that agriculture plays a central role in this country's economy? Why or why not?

2. What economic activities other than agriculture are important to this country's economy?

3. What challenges or problems does this country face in its agricultural industry?

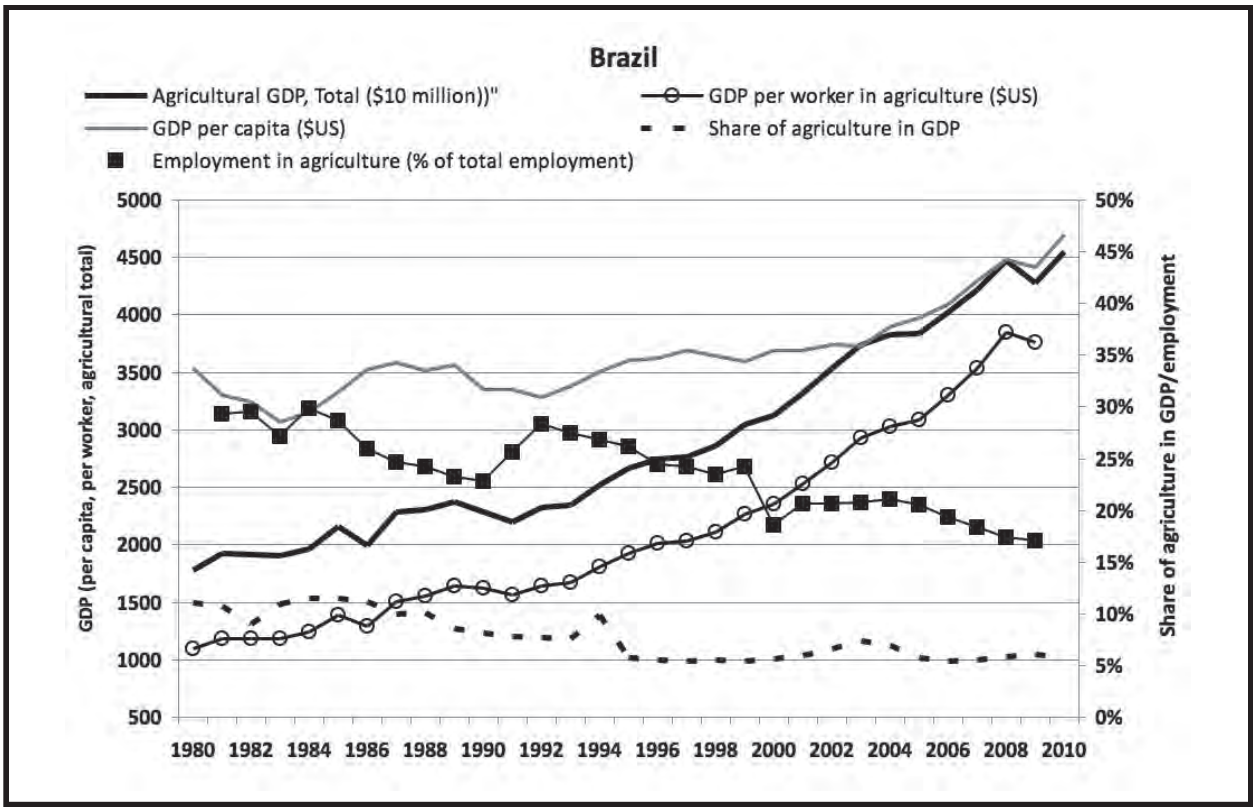
4. According to the most recent data you can find, what is the poverty headcount ratio ($1.25 per day) in this country? How does this value compare with your approximation in (5) above? How might you explain any major discrepancy?

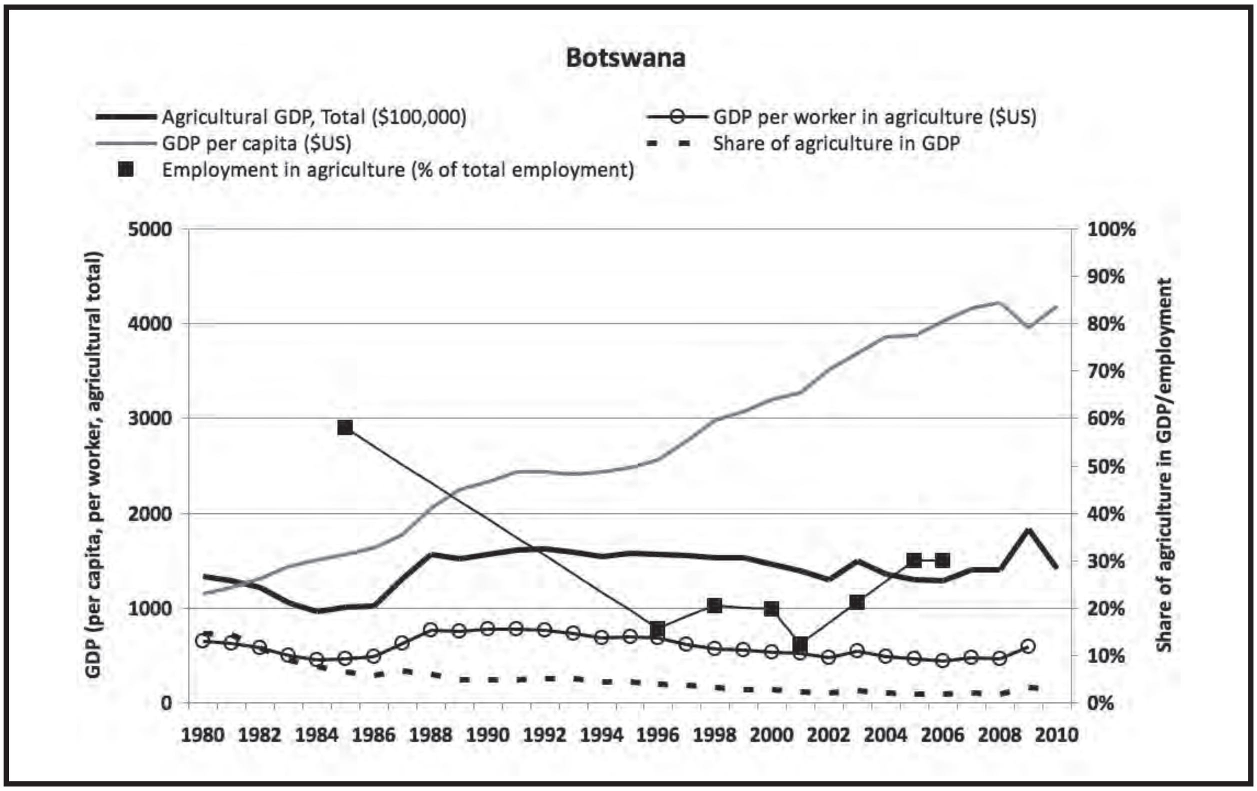
Final group discussion question: In this lesson, you have seen that agricultural productivity is often — but not always — correlated with macroeconomic development: higher national GDP, more economic activity in higher value sectors, and lower poverty rates. Based on your work in this exercise, propose one of the following development strategies for each of the four countries your class has studied:

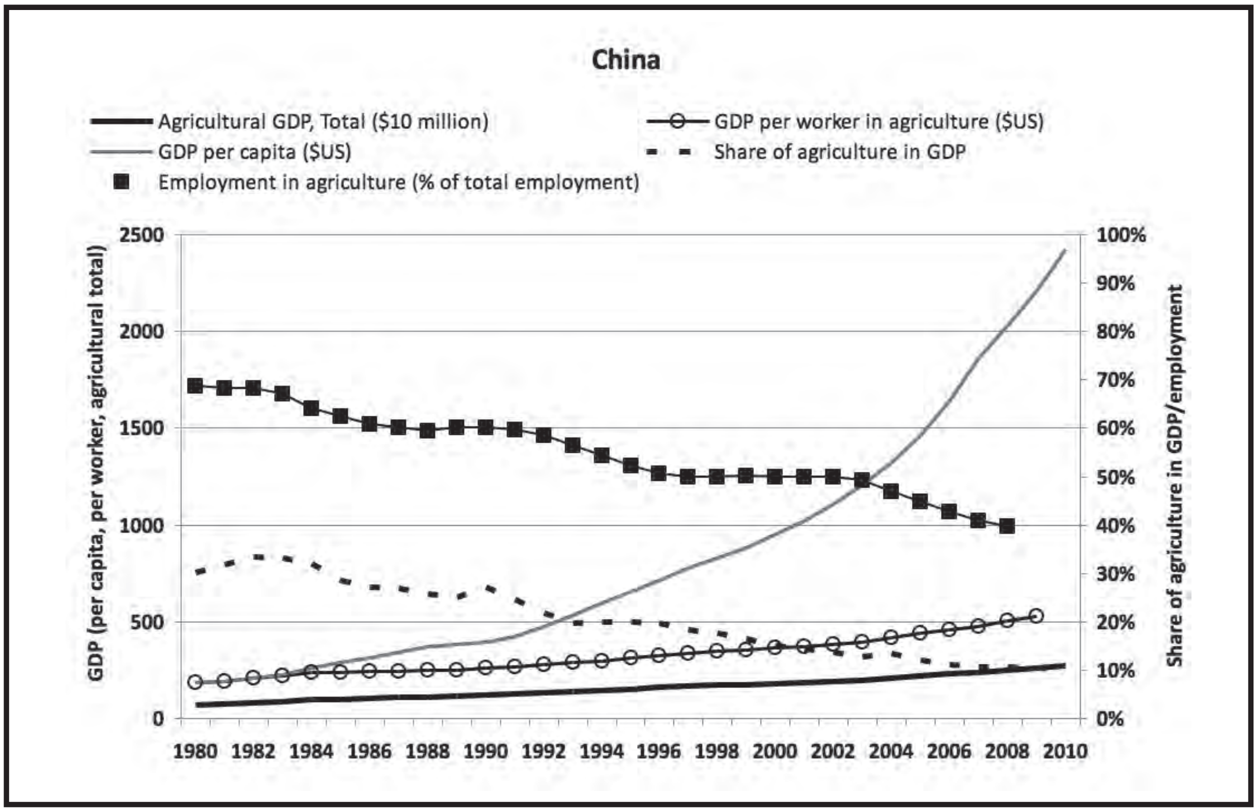
- The country's agricultural industry is underdeveloped; the government should invest in increasing productivity and worker incomes in agriculture.
- The country's agricultural industry is sufficiently developed; the government should invest in diversifying the economy and increasing productivity and worker incomes in other industries.
- The country lacks resources necessary to develop the agricultural sector; the government should invest in diversifying the economy and increasing productivity and worker incomes in other industries.
- The country has already attained a high level of overall development; the government should invest in improving equality and protecting natural resources to ensure that development will be sustainable.

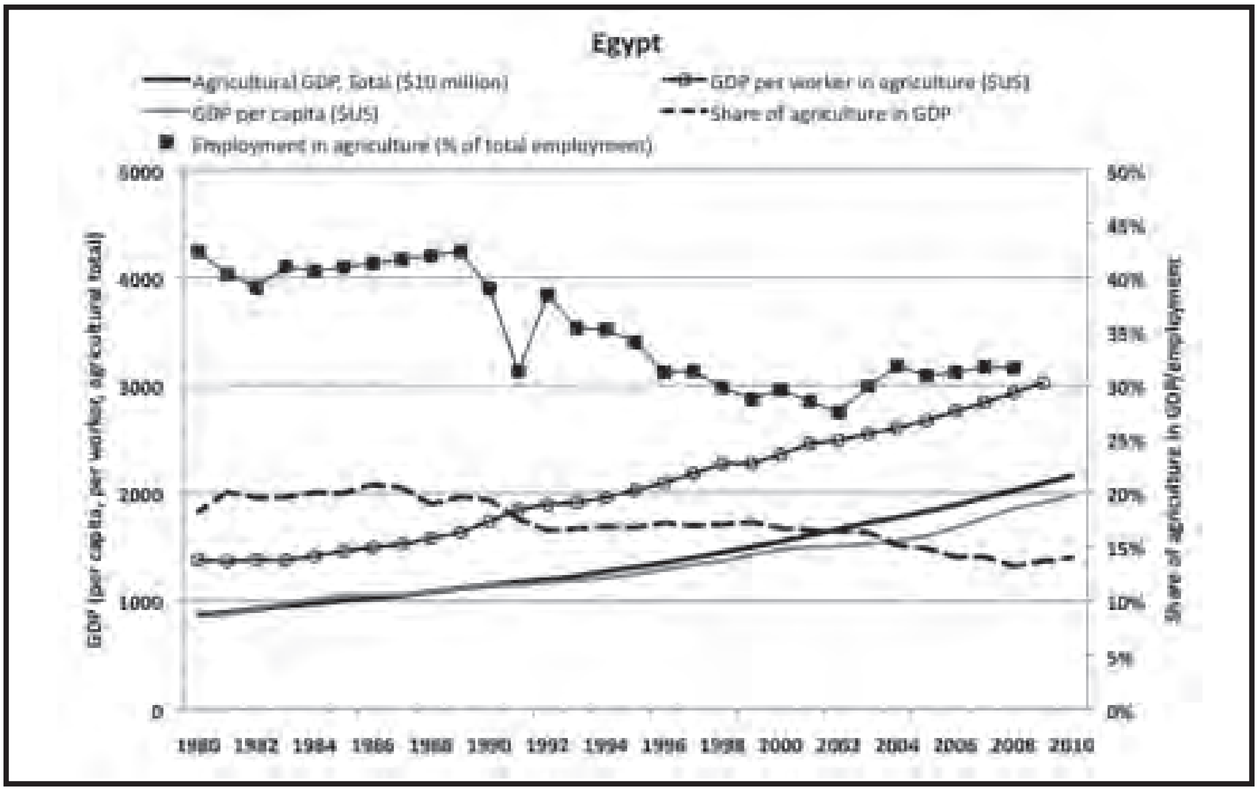
Be prepared to give specifics (e.g., industries other than agriculture that the government should invest in) and to back up your proposal with a logical argument.

Country Case Study Data






China
Agricultural GDP, Total ($10 million)
GDP per capita ($US)
Employment in agriculture (% of total employment)
GDP per worker in agriculture ($US)
Share of agriculture in GDP
GDP (per capita, per worker, agricultural total)
Share of agriculture in GDP/employment
0
500
1000
1500
2000
2500
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010


Egypt
Agricultural GDP, Total ($10 million)
GDP per capita ($US)
Employment in agriculture (% of total employment)
GDP per worker in agriculture ($US)
Share of agriculture in GDP
GDP (per capita, per worker, agricultural total)
Share of agriculture in GDP/employment
0
1000
2000
3000
4000
5000
0%
5%
10%
15%
20%
25%
30%
35%
40%
45%
50%
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010

Quiz

1. Give an example of an economic activity that belongs to the:

a. Primary sector:

b. Secondary sector:

c. Tertiary sector:

2. Which of the following goods and services would NOT be included in a country's GDP? Circle all that apply:
   a. Paper used by a publishing company to make textbooks
   b. Computers assembled and sold in the country using foreign parts
   c. Designer clothing imported from foreign manufacturers
   d. The price of a museum tour in the country's capital city
   e. Pastries baked and sold in a café in the country's capital city

3. In general, as the share of a country's workforce employed in agriculture decreases, GNI per capita _____________ and poverty rate _____________.

4. In Country A, an international development agency implements a program to help small farmers install irrigation systems. Explain how this program might affect the owner of a small clothing shop in a nearby town. List all possible effects — think broadly!

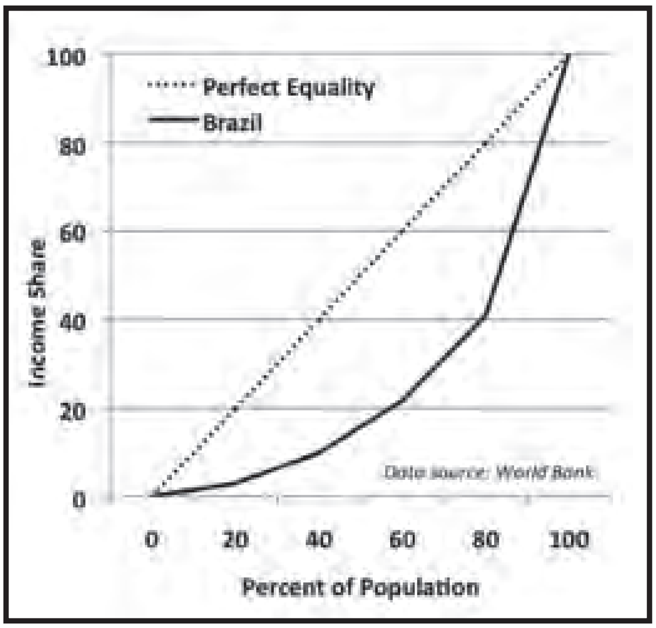
Inequality Data Activity

Introduction

High poverty rates at the household level may reflect poverty (low GDP) at the national level; however, some countries with high GDP also have high poverty rates. In this case, household poverty reflects national *inequality* — although the total national income would support a high standard of living for all households if distributed equally, a small percentage of the households hold most of the income, leaving remaining households in poverty.

As with poverty, economists may use any of several measures to express the degree of inequality in a country. One simple way to measure inequality is to take a ratio of income shares. For example, suppose we find that the poorest 10 percent of a country's population earn just 1 percent of the national income, while the richest 10 percent earn 40 percent. Dividing 40 by 1 (top 10 percent's share by bottom 10 percent's share), we would give this country an inequality "score" of 40. In more concrete terms, if this country had a total population of 100 persons and a total national GDP of $1,000 per year, the 10 poorest citizens would together earn only $10 ($1 per person), while the richest 10 would earn $400 ($40 per person).

We can also construct a visual representation of inequality by graphing income share against cumulative population. See the graph below for an example:



Gini coefficient–a quantitative metric of national income inequality, with 0 indicating perfect equality (all citizens of the country earn equal income) and 1 (or 100) indicating perfect inequality (one citizen earns 100% of the country's income)

This graph shows actual data from the South American country of Brazil, a country known for its income inequality. Note the point (80,40) on the graph, indicating that the poorer 80 percent of Brazil's population holds only 40 percent of the income. Also note the dashed line labeled "perfect equality." Along this line, the population and income shares are exactly equal — in our example above, each of the 100 citizens would earn exactly 1 percent of the total income, or $10. The area between this line and an individual country's income distribution curve is another measure of inequality, called the Gini coefficient.

Activity Instructions

Part One:

The graph below shows measures of national income and poverty for several different countries. The countries are sorted from left to right according to poverty rate (highest poverty rate on the left, lowest on the right). Pay close attention to the following definitions given in the legend:

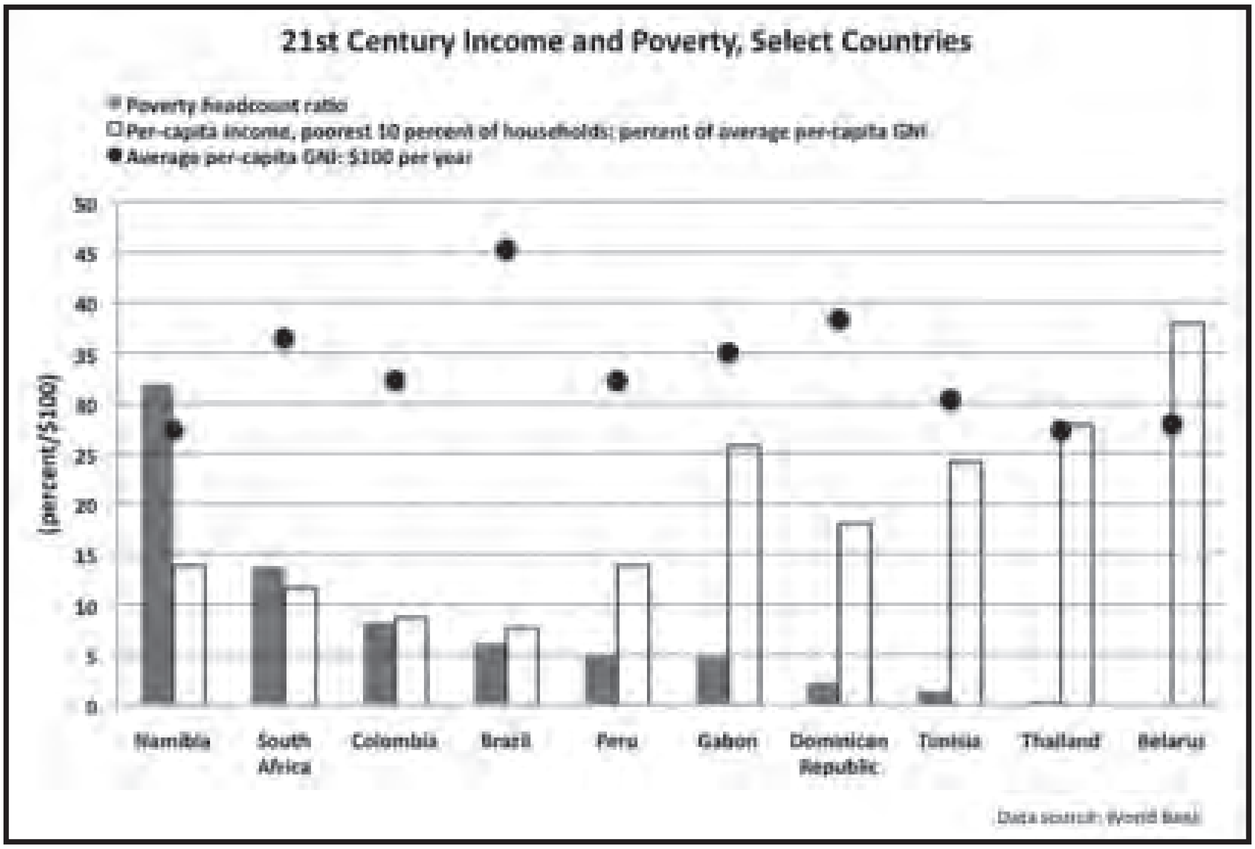
- The height of the gray bar indicates the country's $1.25 per day poverty headcount ratio, as a percentage of population
- The height of the black dot indicates the average annual income of all individuals in the country (per capita GNI), in hundreds of U.S. dollars
- The height of the white bar indicates the average annual income of an individual in the poorest 10 percent of the country's population, as a percentage of the average annual income of all individuals (i.e., as a percentage of the height of the black dot).

Describe the trends that you see in the graph:

1. Describe any apparent relationship between average GNI and poverty rate in these countries.

2. Describe and explain any apparent relationship between the poverty rate and the relative average income of the poorest 10 percent.

3. Compare and contrast the impact of overall national productivity and income inequality on poverty rates.



Part Two:

The table below contains data on national income, income inequality, and poverty for several countries in each of three global regions. Perform the appropriate calculations to fill in the missing columns in each table. Then, using the axes provided, construct a graph for each region, similar to the graph in Question 3 above. Study your graphs carefully, check for any errors, and answer the questions below.

Questions:

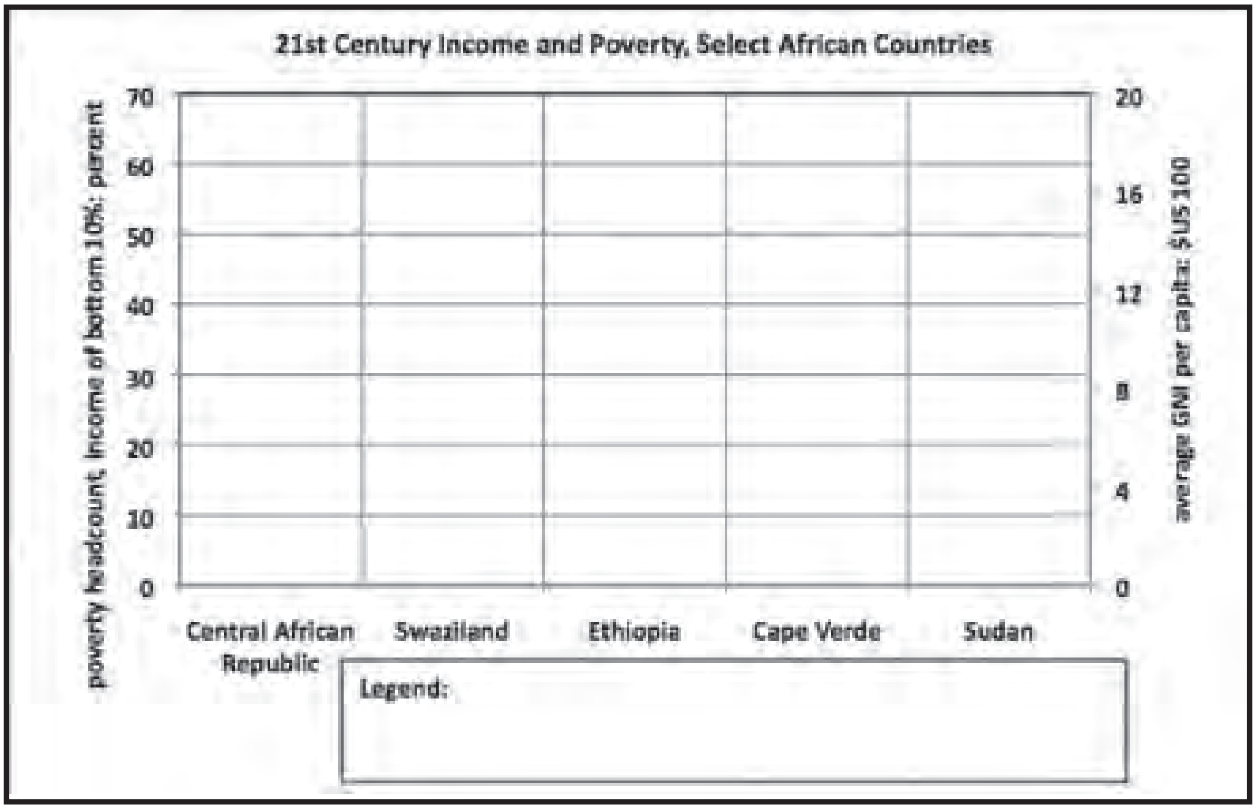
1. Compare and contrast the three regions with respect to the measures given in the data (hint: If you refer to your graphs when making comparisons, be sure to consider the axis scales!):
   a. Which region has the lowest average per capita GNI levels? The highest?
   b. Which region has the greatest income inequality? The least?
   c. Which region has the highest poverty rates? The lowest?

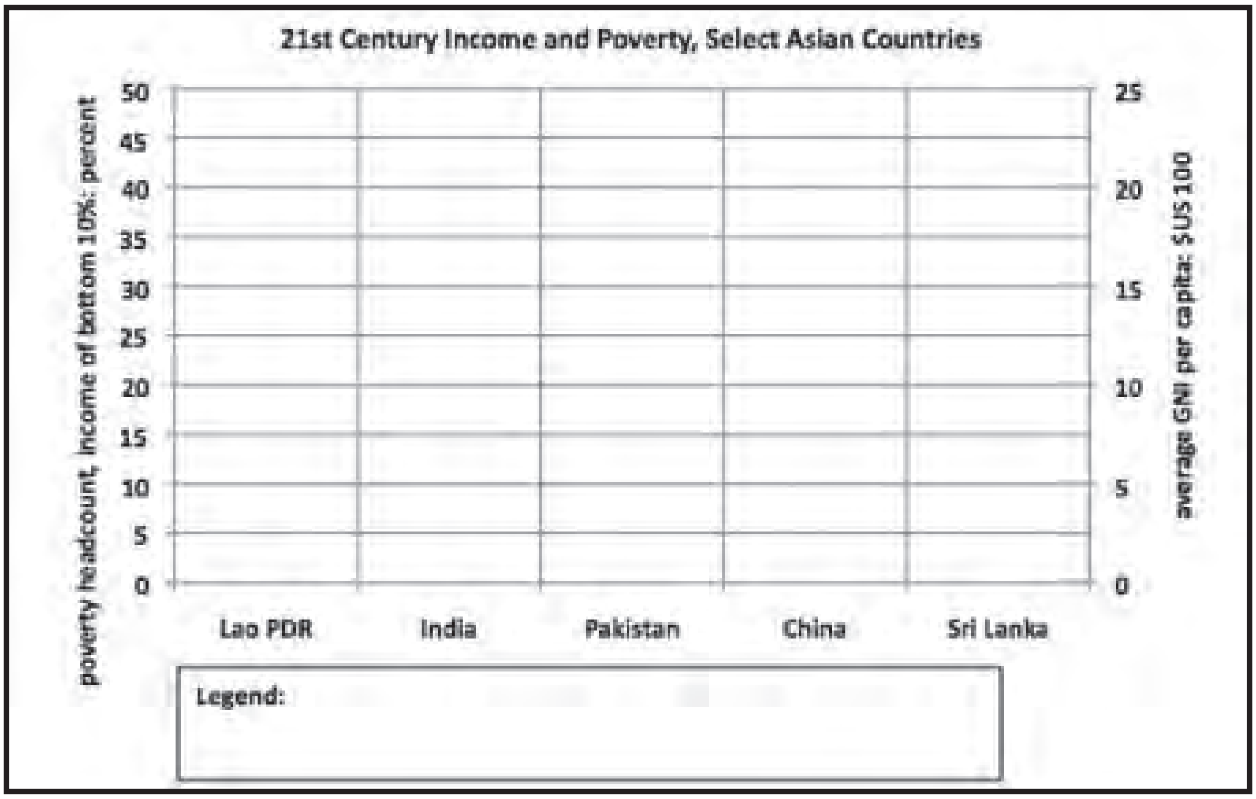
2. The poverty rate should decline as you move from left to right across each graph. For each region, describe how average GNI and income inequality change as poverty declines. Explain the trends you observe.

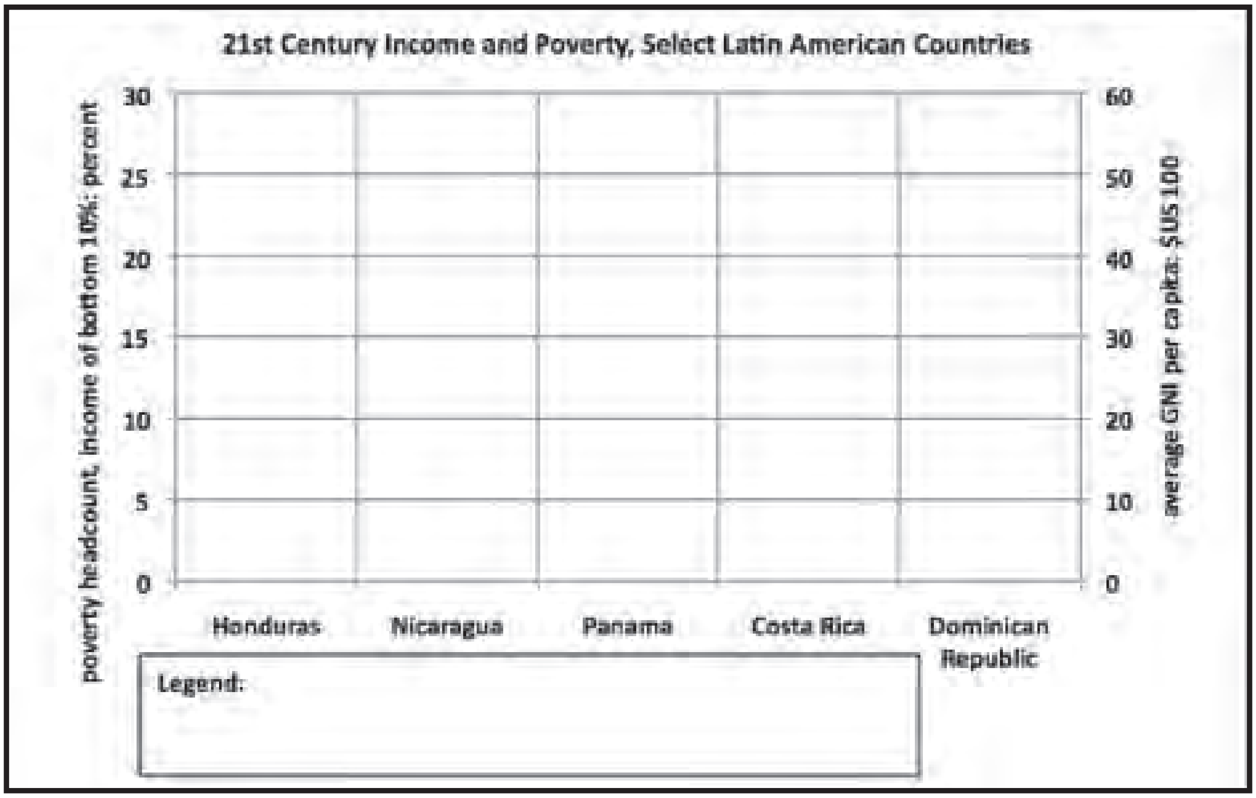
	Poverty headcount ratio ($1.25/ day)	Annual GNI ($U.S. billions)	Total population	Income share held by bottom 10% (%)	Income per person, bottom 10% ($U.S.) (1)	GNI per capita, average ($U.S.)	GNI per capita, average ($U.S. 100)	Income per person, bottom 10% (% of average per capita GNI)
Africa								
Central African Republic	62.83	0.93	4401051	1.22				
Swaziland	40.63	2.13	1186056	1.66				
Ethiopia	38.96	18.12	82949541	4.05				
Cape Verde	21.02	0.75	495999	1.88				
Sudan	19.80	19.17	43551941	2.74				
Asia								
Lao PDR	33.88	3.34	6200894	3.34				
India	32.67	950.65	1170938000	3.75				
Pakistan	21.04	109.19	173593383	4.36				
China	13.06	3152.61	1338299512	1.79				
Sri Lanka	7.04	26.39	20859949	3.05				
Latin America								
Honduras	17.92	10.48	7600524	0.43				
Nicaragua	11.91	5.15	5788163	2.61				
Panama	6.56	19.78	3516820	1.10				
Costa Rica	3.12	21.17	4658887	1.23				
Dominican Republic	2.24	38.08	9927320	1.81				

(1) Hint: Use columns 2 and 4 to calculate the total income held by the poorest 10% of the population; use column 3 to calculate the number of people in 10% of the population; take a ratio

Data Source: World Bank


21st Century Income and Poverty, Select African Countries
poverty headcount, income of bottom 10%: percent
70
60
50
40
30
20
10
0
20
16
12
8
4
0
average GNI per capita: $US 100
Central African Republic
Swaziland
Ethiopia
Cape Verde
Sudan
Legend:


21st Century Income and Poverty, Select Asian Countries
poverty headcount, income of bottom 10%: percent
50
45
40
35
30
25
20
15
10
5
0
25
20
15
10
5
0
average GNI per capita: $US 100
Lao PDR
India
Pakistan
China
Sri Lanka
Legend:


21st Century Income and Poverty, Select Latin American Countries
poverty headcount, income of bottom 10%: percent
30
25
20
15
10
5
0
60
50
40
30
20
10
0
average GNI per capita: $US 100
Honduras
Nicaragua
Panama
Costa Rica
Dominican Republic
Legend:

Answer Key to Handout 1 (Introduction and Key Terms)

Sector (Primary/Secondary/Tertiary)

Classify the following productive activities as belonging to the primary, secondary, or tertiary sector of an economy.

1. Family employees sewing clothes as a part of a small home business
   Secondary
2. Factory workers canning produce
   Secondary
3. Miners extracting iron ore
   Primary
4. A teacher instructing primary students
   Tertiary
5. Field workers harvesting crops
   Primary
6. A bank employee assisting customers with accounts
   Tertiary
7. A tour guide teaching visitors about an area's wildlife
   Tertiary
8. Construction workers building a new home
   Secondary

Gross Domestic Product (GDP) and Gross National Income (GNI)

Indicate whether the following goods and services would be included in the U.S. GDP:

1. A meal served in a U.S. restaurant
   Yes
2. Tutoring services provided by a private company in a large U.S. city
   Yes
3. Berries picked by a farmer in California, who then sells them to a local canning company that makes and sells jam
   No — the berries are not a final good (the jam is the final good).
4. A computer manufactured in Japan and sold in the United States
   No — this is not a good produced within the country
5. A shirt made by a U.S. company using fabric woven in South America
   Yes — the final good (the shirt) is manufactured and sold within the country.
6. Flour milled in the U.S. Midwest and purchased by a home baker, who uses it to make muffins to give to her neighbors
   Yes — although the baker uses the flour as an input, because she does not sell the output, the flour is the last (final) good that has measurable market value.

Answer Key to Handout 2 (Key Terms Discussion and Graph Analysis)

1. Do you think GDP and GNI are good overall measures of a country's productivity? What goods or services might be overlooked in these measures? Are there other reasons that GDP and GNI might overestimate or underestimate the value of a country's output?
   Answers may vary. Award points for thoughtful, logical responses that reflect an understanding of the definition of GDP/GNI.
   Some commonly noted omissions from GDP/GNI include:
   - *Informal transactions — the value of gifts, goods, and services exchanged in nonmonetary trades, etc.*
   - *Volunteer or unpaid labor — raising children is one common example*
   - *Environmental or social costs/benefits (e.g., pollution) that are not reflected in the price paid for a product or the income earned by its producer*

2. The graph below shows sector-by-sector employment shares, GNI per capita, and poverty headcount ratios for several different countries.
   a. Describe and explain any apparent relationship between employment in services and GNI per capita in these countries (refer to Handout 2 to inform your explanation).
   GNI per capita appears to be higher in countries in which the employment share in services is also high. This is most likely because the service sector, or tertiary sector, is engaged in adding value to the products of the primary and secondary sectors — producing higher value products that command a higher price. Because countries with a high employment share in the service sector produce the highest–value output, they also earn the highest incomes.
   b. Describe and explain any apparent relationship between employment in agriculture and poverty rate in these countries. Have you seen this relationship before? (Hint: Think back to Part 1 of Lesson Four).
   Poverty appears to be higher in countries in which the employment share in agriculture is also high. This observation supports the conclusion above — countries that produce lower value products tend to have lower incomes and higher poverty rates. As discussed in Part One of Lesson Four, this correlation is an important factor in the "food price dilemma"— high food prices raise the incomes of farmers in poor countries but simultaneously hurt poor populations who cannot afford to pay more for food.
   c. Describe any apparent relationship between GNI per capita and poverty rate in these countries.
   GNI and poverty rate appear to be negatively correlated — that is, as GNI increases, poverty rate decreases. This correlation is expected, as poverty is determined by income and GNI per capita is a measure of the overall income level in the country.
   Note: This correlation depends on a reasonably equal income distribution. A country with a very unequal income distribution may have both average high GNI per capita and a high poverty rate. The Optional Data Activity explores this concept in greater depth.

Answer Key to Handout 3 (Agriculture and Economic Development)

Exercise

The graph below shows national average output per worker (GDP per capita), output per worker in the agricultural sector (the value of output produced by each agricultural worker), and employment share in agriculture for several countries.

1. Why was it necessary to show the developed economies (U.S., Sweden, and Australia) in a separate graph? Describe the major differences between developed and developing economies, as indicated by the data in this graph.
   The developed economies are shown on a separate graph because their output per worker is an order of magnitude higher than that of the developing economies ($20,000–$60,000 as opposed to $500–$5,000) and their employment shares in agriculture are an order of magnitude lower (2–4 percent as opposed to 20–80 percent).

   In general, we can see from the data shown that these developed economies have higher output (both in agriculture and overall) and lower employment shares in agriculture than the selected developing economies. We can also see that output per worker in agriculture appears to be higher than overall output per worker in the developed economies shown but lower in the developing economies shown. Note: Be sure students recognize that these countries may or may not be representative of global trends. Correct any answers that refer to "developed" and "developing" economies in general, without using appropriate qualifying language that limits conclusions to the data in the figure.

2. Describe the apparent relationship between employment in agriculture and output per worker in agriculture. What does this relationship indicate about each country's total agricultural output?
   In general (there are exceptions), it appears from the figure as though output per worker in agriculture rises as employment in agriculture declines. This would indicate that each country's total agricultural output is roughly the same, or at least that a lower employment share is not necessarily accompanied by lower total output.

Students should recognize that there are many caveats to this claim — the total output depends on the total agricultural workforce (which is related through employment share to the country's population) and to the relative magnitude of the differences between countries in employment share and output per worker. The key point that students should take from the question, as stated above, is that output may rise or remain steady even as employment share falls, if worker efficiency increases. In other words, a country can feed itself either by employing a high share of its population in agriculture or by producing food very efficiently.

3. Describe the apparent relationship between average GDP per capita and agricultural output per worker.
   Overall, for the countries shown, GDP per capita and agricultural output per worker appear to be positively correlated (countries with a higher average output per worker tend also to have a high output per worker in agriculture).

4. Describe any exceptions to the relationships you observed in questions 2 and 3. What might

account for these exceptions?
Sweden has a slightly higher employment share in agriculture than the United States and also a slightly higher agricultural output per worker.

The Philippines has a lower average output per worker than China but a higher agricultural output per worker.

Explanations will vary — reward students for logical, creative, and detailed responses that demonstrate an understanding of the relationships between output, employment share, and worker efficiency. Good explanations include differences in population (e.g., Sweden's population is much smaller than that of the U.S. population — therefore, a higher employment share still represents fewer workers, who must therefore work more efficiently) and other dominant higher value industries (e.g., China has a large manufacturing industry, which may drive average output per capita far above agricultural output per capita).

5. How do you think that the process of agricultural production differs between Madagascar and the United States? Think about the type of crops grown, equipment and inputs used, scale of production, etc. Be sure to explain how the data in the graph shaped or supports your conclusions.
Students should recognize that in countries in which agricultural output per worker is higher (e.g., the U.S.), production must be more labor–efficient. This means more use of equipment and mechanization in land preparation, planting, and harvest. Farms are likely to be larger, since a single business or family can cultivate a large area of land when aided by more advanced equipment. Crops will be either basic staples (corn, rice, wheat, and soy) that can be grown in fast rotations thanks to fertilizers, pesticides, and crop engineering, or specialty high–value crops such as nuts and fruit, which require more time and attention but fetch a high price in local and global markets.

In countries like Madagascar, where output per worker is low, farming is most likely carried out by hand or with simple tools on small family plots. Although some staples will be grown, "orphan crops" (see Lesson Two) such as cassava and sorghum may also be prevalent. Specialty crops will be much less common.

Begin by discussing the following question:

Can a poor country increase in wealth without improving the efficiency of agricultural production? Why, or why not? Be sure to discuss arguments on both sides. Consider:

- other resources or productivity improvements that could accelerate macroeconomic development;
- how the historical period in which development takes place (e.g., 19th century vs. 21st century) might affect the development process and the importance of agricultural production efficiency; and
- the long-term consequences of "skipping" the agricultural phase of economic development.

The following ideas may help to drive this discussion:

- *A country that cannot feed its citizens cannot afford to put resources into the development of higher value industries (as described above)*

- *Some countries may be prevented by climate or land availability from developing a productive agricultural sector*
- *In today's globally connected economy, it is easier for countries to trade for what they need — if a country has other primary resources (oil is a good example), it may be able to trade for agricultural products with other countries*
- *Countries that never develop a strong agricultural sector will be less self–reliant*
- *Countries that never develop a strong agricultural sector will not have to deal with environmental problems associated with industrial agricultural production.*

Do you know of any examples of countries that developed from an "agricultural base," i.e., that began as agricultural economies and expanded rapidly when food production efficiency increased? Explain.

Students should mention the U.S. and Europe during the Industrial Revolution; in particular, inventions such as the cotton gin and steam engine, which improved the labor efficiency of agricultural production. Southeast Asian economies have also experiences accelerated development since the Green Revolution ended the hunger crises of the 1960s and 1970s.

Answer Key to Handout 5 (Reading Guide: The Comprehensive Africa Agriculture Development Programme)

1. What prompted African leaders to put agriculture on their agendas in 2003?
   A drought emergency in the early part of the 21st century.
   Instructors may wish to engage students in a discussion about how agricultural development could ease the impact of future droughts — for example, improved productivity in good weather years would allow countries to build up grain stores to draw on in drought years; agricultural research might lead to the development of drought tolerant crops.

2. How much money did African governments pledge to allocate to agricultural development? Does this seem like a large amount of funding to you? Why or why not?
   10 percent.
   Student responses will vary — award points for logical, well-reasoned explanations. Students might consider other categories of government spending (health care, education, defense, etc). Exceptional answers will reference relevant budget shares for countries either in or outside of Africa.

3. Explain how agriculture based development could "increase opportunities in the export market."
   Students should recognize that higher production efficiency would allow African countries to produce surplus food, which could be sold in international markets. Students may also recognize that crop research and farmer education could increase cultivation of regional specialty products for export.

4. The CAADP aims to both "end hunger" and to "reduce…food insecurity." Explain the difference between hunger and food insecurity (Lesson One).
   Hunger refers to immediate need; food insecurity refers to vulnerability to hunger, even when immediate food supplies are sufficient.

5. Explain, in your own words, why Dr. Ousmane Badiane believes the CAADP agenda is significant.
   Student responses will vary, but should include the following key ideas in some form:
   - *The CAADP focuses on agriculture*
   - *The CAADP relies on African leadership and funding*

   Excellent responses will reference the next paragraph, noting that development funding since 1980 has focused on education, health, and emergency humanitarian response rather than agriculture and that international investors seem increasingly reluctant to support agricultural development.

6. Drawing on previous handouts and material in this lesson, explain why agriculture can or should be "the centerpiece of growth and poverty-reduction strategies."
   Student responses should reflect an understanding of the material in the "Agriculture and Economic Development" handout. Responses should explain that a country must be able to provide food for its citizens before diversifying and developing other areas of their the economy, and that a productive agricultural industry provides both food for urban (manufacturing and service) workers and a market for urban products.

7. List two statistics from the article that support this statement: “Agriculture is an important part of the African economy.”
   Sixty-five percent of Africans depend on agriculture for a living; agriculture contributes an estimated 30–40 percent of African GDP.

8. List two statistics from the article that support this statement: “Funding for agricultural development in Africa declined between 1980 and the beginning of the 21st century.”
   Public investment in the sector fell from 6.4 percent to 4.5 percent; the share of international development assistance devoted to agriculture fell from 26 percent to 4 percent.

9. In what areas did African leaders focus public spending between 1980 and 2000? Do you think that they made the right decision? Why or why not?
   Education and health.
   Student responses will vary. Students may argue that governments should have focused on agriculture, because an unfed population will be less healthy and will not benefit from education. However, students may also argue that education and good health can help to advance agricultural productivity — and will be more important if the country does not have a large agricultural resource base. Award points for logical arguments that are grounded in the lesson material.

10. Explain what the article means by “advanced seed technology” (Lesson Two).
    The authors are most likely referring to hybridized or genetically engineered crops that grow well in local soils and under local climatic conditions. Asia and Latin America benefitted enormously from Green Revolution advances that developed and disseminated such crops, but the scientists of that era largely overlooked African agricultural development.

11. What countries does Africa look to as examples in setting and achieving agricultural development and poverty reduction goals? Why?
    The article mentions that India and China spent about 10 percent of their national budgets on agriculture during the Green Revolution, and suggests that this figure may be the basis for Africa’s 10 percent target. India and China both achieved dramatic advances in crop productivity during the 1960s and 1970s, accompanied by impressive reductions in hunger and poverty

Answer Key to Handout 7
(Reading Guide: Ousmane Badiane Lecture Summary)

1. Badiane feels that despite over a decade of rapid economic growth, African nations still "lag behind the developed world in economic sophistication." Explain what *economic sophistication* might mean in this context. In your explanation, contrast economic sophistication with economic productivity (total GDP).
   Answers will vary somewhat, but students should recognize that economic "sophistication" in this context means developing productive secondary and tertiary industries, and increasing production efficiency across all sectors. Total GDP can increase without such increases in economic "sophistication" — by growing the labor force, for example, or by exploiting untapped natural resources such as uncultivated land — but growth is unlikely to be sustained over the long term without economic diversification and efficiency enhancements.

2. What sector of the African economy does Badiane think has grown too quickly? Can you find evidence for this claim? (Hint: Refer to the graph in Handout 2).
   Badiane claims that the service sector has grown too quickly, particularly in light of its being dominated by low value retail. Handout 2 provides no conclusive evidence that the service sector is low-value or that its growth has outpaced that of the other two sectors. However, we can see that in the two African countries (Uganda and Madagascar), the industrial sector claims a very small share of employment — both relative to the other two sectors in those countries and relative to the industrial employment share in the other countries on the graph. This data therefore might suggest that these African nations have not developed a strong enough industrial sector to support a truly productive service sector (recall that in most economies, the service sector makes use of many outputs of the industrial sector, such as buildings, equipment, transportation and communication infrastructure, etc).

3. Describe two ways that a strong agricultural industry can support industrial development.
   The summary mentions two key ideas, paraphrased here:
   - *When farm incomes increase, farmers can afford to purchase secondary and tertiary products such as clothing, equipment, and education*
   - *Productive local farms provide a stable source of food for the urban population. Instructors may wish to discuss with students some of the advantages of locally produced food, recalling ideas about transport cost from Part One of Lesson Four.*

   Some students may also recognize, drawing on the vignette that opens the summary, that a transfer of labor will take place between the rural and urban economies as food production efficiency improves; i.e., workers who are no longer needed on the farm will seek jobs in growing urban industries. This transfer will be mutually beneficial if it occurs in pace with urban and industrial development; a rush of workers from farm to factory, however, will depress urban wages and degrade urban living conditions.

4. What other objectives might compete with agricultural development for government financing?
   The summary mentions "public welfare programs" in general, and health and education services in particular. The instructor may wish to discuss with students any other government programs that would suffer and which programs they think would most likely have funding cut as funding for

agriculture increased. Students might also investigate the statistic given by Dr. Joel Samoff, verifying the level of health-care expenditure in various African countries and comparing it to the level in other developing and developed regions.

5. How does Badiane suggest that African governments approach the competition for public funds? Explain how this approach might affect a new national health-care policy.
   Badiane suggests that African governments "Look at health and education not as an entitlement, but as a tool to raise labor productivity." In other words, social welfare policies should be designed in such a way as to make workers more productive — in agriculture and ultimately in secondary and tertiary industries as well.
   Answers to the second part of this question will vary but should outline some way in which the government might target the policy to make workers more productive. For example, they might set aside some portion of the health-care budget to provide low-cost health care in rural areas, in the hopes of reducing health effects on farm productivity.

(For discussion or extra credit):

Answers will vary; these questions are designed to provoke reflection on the process of writing a news summary, and on the broader connections between Badiane's ideas and the unit material. Award credit for thoughtful responses and active participation in discussion.

- Why do you think that the author of the article began with the story of the seamstress and the farmer? Do you think the story is effective? Explain.
- What would you change about this news summary? What questions would you have for the author or the speakers that the summary leaves unanswered? Explain.

Answer Key to Handout 8 (Country Case Study)

In this activity, you will work in small groups to examine macroeconomic structure and development in a particular country. You will use World Bank data (the chart below) and your own research to evaluate the contributions of different sectors and industries in your country's economic development between 1980 and 2010. The exercise is intended to give you a better understanding of the importance of agriculture in the economies of various countries, and of the changes that take place in a country's economy as agricultural production efficiency improves. You will also have an opportunity to apply the macroeconomic vocabulary and concepts that you have learned in this lesson.

Use the graph provided for your country to answer the following questions:

1. Did the labor efficiency of agricultural production increase in this country between 1980 and 2010? How can you tell?
   Answers should focus on changes in the GDP per worker in agriculture. If GDP per worker increased, the labor efficiency of production increased.
   - *Brazil: Yes*
   - *Botswana: No*
   - *China: Yes/Slightly*
   - *Egypt: Yes*

2. Did economic activity in industries other than agriculture increase in this country between 1980 and 2010? How can you tell?
   Answers should compare the change in the share of agriculture in GDP with the change in total GDP from agriculture. If total GDP increased, but the share in GDP declined, we can conclude that economic activity outside agriculture increased.
   - *Brazil: Yes*
   - *Botswana: No/Unclear/Slightly*
   - *China: Yes*
   - *Egypt: Yes*

3. Describe how per capita incomes changed in this country between 1980 and 2010.
   Answers should focus on changes in GDP per capita (i.e., per capita income).
   - *Brazil: Increased (by about $1,000 per person per year)*
   - *Botswana: Increased (by about $3,000 per person per year)*
   - *China: Increased (by about $2,000 per person per year)*
   - *Egypt: Increased (by about $1,000 per person per year)*

4. Compare the changes in average per capita income to the changes in GDP per worker in agriculture (i.e., income per capita in agriculture). Did one increase more quickly than the other? Is one significantly higher than the other?
   - *Brazil: Both increased; GDP per worker in agriculture increased more/faster between 1980 and 2000, but the trends are more similar between 2000 and 2010. Overall GDP per capita is higher*

than GDP per worker in agriculture.

- *Botswana: GDP per capita increased rapidly; GDP per worker in agriculture increased slowly/not at all. Overall GDP per capita is higher than GDP per worker in agriculture.*
- *China: Both increased; GDP per worker in agriculture increased slightly/slowly, while overall GDP per capita increased very quickly. Overall GDP per capita in GDP per worker in agriculture were similar in 1980, but GDP per capita is now much higher.*
- *Egypt: Both increased at a similar rate. GDP per worker in agriculture is slightly higher than overall GDP per capita.*

5. Based on (a) the percentage of your country's workforce employed in agriculture, and (b) your country's per capita GDP, approximate your country's 21st-century poverty rate. (Hint: Refer to Handout 2, and compare your country's employment share and GDP per capita to those of the countries shown in the Handout 2 graph).

   a. Brazil: 5–10 percent; Botswana: 15–20 percent; China: 20–30 percent; Egypt: 15–20 percent

   b. Brazil: 5–10 percent; Botswana: 5–10 percent; China: 10–15 percent; Egypt: 10–15 percent

   Do your approximations based on the two measures differ? Which do you think is closest to the correct value? Why?
   Students should accurately describe differences and similarities in the two estimates. Answers to the second part of the question will vary; award points for logical arguments that are grounded in the lesson material.

6. Challenge question: in some countries, the share of agriculture in employment is higher than the share of agriculture in GDP; in others, the GDP share is higher than the employment share. Which is more desirable from a production efficiency and development perspective? What does it mean for the two shares to be exactly equal?
   In general, it is desirable for the GDP share to be higher than the employment share. When the two shares are exactly equal, we know that each agricultural worker is producing exactly as much output as the average worker in the economy: e.g., 10 percent of the workers are producing 10 percent of the output. As the employment share declines relative to the GDP share, we know that fewer workers are producing more agricultural output, indicating an increase in the efficiency of agricultural production. Ultimately, of course, the GDP share should also decline as workers leave agriculture for higher value industries; but any shift of labor out of agriculture should be driven by efficiency increases, and thus the employment share will decline more quickly than the GDP share. See the graph at the end of Handout 3 for a visual representation of this process.

Research your country's history and economy, beginning with the following Web pages:

- The World Bank's "Countries" page: www.worldbank.org;
- The U.Ss State Department's country background notes: http://www.state.gov/misc/list/index.htm;
- The U.S. Central Intelligence Agency World Factbook: https://www.cia.gov/library/publications/the-world-factbook/index.html

Much of the information on these pages is detailed and technical. Skim the pages for information relevant to this lesson, focusing on answering the following questions:
Answers in this part of the exercise will vary. The notes below are intended to help instructors check the general structure and focus of responses, and to verify key details. In general, instructors should award

credit for research effort and for logical, creative responses that are grounded in the lesson material.

1. Would you say that agriculture plays a central role in this country's economy? Why or why not?

   Answers should focus on any of the following:

   - *the share of agriculture in employment, GDP, and trade;*
   - *whether the country is well endowed with natural resources (land, water, fertile soil) that make it especially suited for productive agriculture;*
   - *whether the country is a major global producer of particular agricultural products (including livestock); or*
   - *other industries that play a dominant role in the economy (next question) and compete with agriculture for labor and other resources.*

2. What economic activities other than agriculture are important to this country's economy?

   Answers will vary by country; some possible answers are listed below:

   - *Brazil: Oil, biofuel, and chemical production; machinery and auto parts manufacturing; information technology and telecommunications*
   - *Botswana: Mining, tourism*
   - *China: Manufacturing (especially consumer products such as apparel and electronics); mining and ore processing (iron, steel, and coal production)*
   - *Egypt: Oil and gas production; tourism*

3. What challenges or problems does this country face in its agricultural industry?

   Answers will vary by country; some possible answers are listed below:

   - *Brazil: Deforestation and greenhouse gas emissions*
   - *Botswana: Low productivity, decline in the cattle industry (main agricultural export)*
   - *China: Climate change, water shortages, low farm incomes, lack of infrastructure*
   - *Egypt: Climate change (soil salinity, water resources)*

4. According to the most recent data you can find, what is the poverty headcount ratio ($1.25 per day) in this country? How does this value compare to your approximation in (5) above? How might you explain any major discrepancy?

   Poverty rates from the World Bank are as follows:

   - *Brazil: 6.1 percent (2009)*
   - *Botswana: 31.2 percent (1994)*
   - *China: 13.1 percent (2008)*
   - *Egypt: 1.7 percent (2008)*

   Students should accurately compare these values to their estimates in the first part of the exercise. For Botswana and Egypt, in particular, students should recognize that employment in agriculture and per capita GDP do not appear to be good predictors of poverty rate. Students should clearly articulate a possible explanation for the discrepancy in a sentence or two; award points for logical, creative explanations that are grounded in the lesson material. In the case of Egypt, students may note (based on their research) that the country's rich agricultural resources allow for an unusually productive *farm lifestyle; thus, a high employment share in agriculture does not preclude a low poverty rate.*

Final discussion question (as a class): In this lesson, you have seen that agricultural productivity is often — but not always — correlated with macroeconomic development, e.g., higher national GDP, more economic activity in higher-value sectors, and lower poverty rates. Based on your work in this exercise, propose one of the following development strategies for each of the four countries your class has studied:

- The country's agricultural industry is underdeveloped; the government should invest in increasing productivity and worker incomes in agriculture.
- The country's agricultural industry is sufficiently developed; the government should invest in diversifying the economy and increasing productivity and worker incomes in other industries.
- The country lacks resources necessary to develop the agricultural sector; the government should invest in diversifying the economy and increasing productivity and worker incomes in other industries.
- The country has already attained a high level of overall development; the government should invest in improving equality and protecting natural resources to ensure that development will be sustainable.

Be prepared to give specifics (e.g., industries other than agriculture that the government should invest in) and to back up your proposal with a logical argument.
Students should ground their arguments in their research and in the lesson material. Evaluate students' responses based on logic, creativity, and contribution to productive class discussion.

Answer Key to Handout 10 (Quiz)

1. Give an example of an economic activity that belongs to the:
   a. Primary sector:
   b. Secondary sector:
   c. Tertiary sector:

   Answers will vary. See Handout 1 for examples and an explanation of the primary, secondary, and tertiary sectors.

2. Which of the following goods and services would NOT be included in a country's GDP? Circle all that apply:
   a. Paper used by a publishing company to make textbooks
   b. Computers assembled and sold in the country using foreign parts
   c. Designer clothing imported from foreign manufacturers
   d. The price of a museum tour in the country's capital city
   e. Pastries baked and sold in a café in the country's capital city

   Paper used to make textbooks is an intermediary, not a final, good, and thus is not counted in GDP. Imported clothing is not produced in the country, and thus is not included in GDP. For a complete explanation and definition of GDP, refer to Handout 1.

3. In general, as the share of a country's workforce employed in agriculture decreases, GNI per capita *increases* and poverty rate *decreases*. *For a complete explanation, see Handout 3.*

4. In Country A, an international development agency implements a program to help small farmers install irrigation systems. Explain how this program might affect the owner of a small clothing shop in a nearby town. List all possible effects — think broadly!

   Answers will vary somewhat; award points for creative thinking and logical explanations that reflect understanding of the lesson content. Students should recognize that the irrigation systems (assuming they are effective) will decrease farmers' production costs and increase farm output, and should recognize at least one of two key consequences for the shop owner:

   - *Farmers will have more disposable income, increasing local demand for the shop owner's products; and*
   - *The drop in food production costs, and increase in production quantity, will cause food prices to fall, reducing the shop owner's costs to purchase food and increasing his or her disposable income.*

ANSWER KEY TO HANDOUT 11 (INEQUALITY DATA ACTIVITY)

Part One:

Describe the trends that you see in the graph:

1. Describe any apparent relationship between average GNI and poverty rate in these countries.
   Since both poverty and GNI reflect per capita income, we would expect to see a decline in the poverty rate as GNI increases. However, there does not appear to be any consistent relationship between GNI and poverty rate for the countries shown here. The country with the lowest poverty rate, Belarus, has close to the same GNI as the country with the highest poverty rate, Namibia.

2. Describe and explain any apparent relationship between the poverty rate and the relative average income of the poorest 10 percent.
   There is an apparent negative correlation — as the relative average income of the poorest 10 percent increases, the poverty rate declines. Because the poorest 10 percent are the most likely to fall below the poverty threshold, the poverty rate declines as their income increases, even if the average per capita income is unchanged.

3. Compare and contrast the impact of overall national productivity and income inequality on poverty rates.
   Students should recognize that GNI per capita is the primary determinant of poverty rates — if a country suffers from general resource deprivation, poverty will persist regardless of the distribution of resources. However, a country with a relatively high GNI per capita may still have a high poverty rate if a small segment of society earns most of the income. In other words, if GNI per capita is held constant, poverty decreases with decreasing income inequality.

Part Two:

Questions:

1. Compare and contrast the three regions with respect to the measures given in the data (hint: If you refer to your graphs when making comparisons, be sure to consider the axis scales!):
   a. Which region has the lowest average per capita GNI levels? The highest?
      Lowest: Africa; highest: Latin America
   b. Which region has the greatest income inequality? The least?
      Greatest: Latin America; least: Asia
   c. Which region has the highest poverty rates? The lowest?
      Highest: Africa; lowest: Latin America

2. The poverty rate should decline as you move from left to right across each graph. For each region, describe how average GNI and income inequality change as poverty declines. Explain the trends you observe.
   - *Africa: GNI per capita alternately increases and decreases; income inequality follows a similar alternating pattern, decreasing, then increasing, then decreasing slightly.*
   - *Latin America: GNI per capita declines slightly, increases sharply, and then declines; income inequality declines sharply, increases slightly, and then declines (excellent responses will recognize that the two measure follow similar trends, with decreases in inequality offsetting decreases in GNI).*

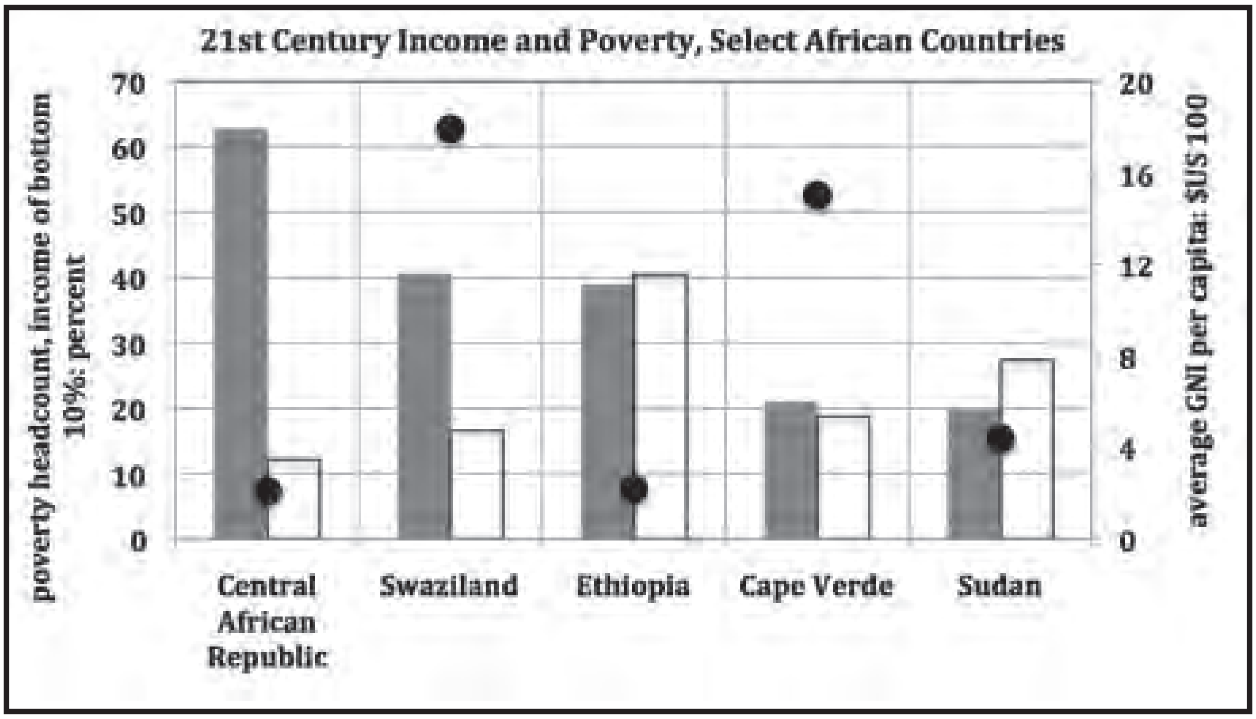
- *Asia: GNI per capita is roughly constant, increases sharply, declines slightly; income inequality decreases slightly, increases sharply, declines (again, we see similar trends).*

In their explanation, students should recognize that changes in equality and GNI have compensating effects: A decrease in inequality can compensate for a decrease in average GNI or vice versa, buffering the effects on the poverty rate.

*Note that differences in the graph scales make it difficult to draw meaningful conclusions regarding the relative magnitude of effects, or to draw comparisons in the effects of inequality and GNI between the different regions. Encourage students to keep their conclusions qualitative.

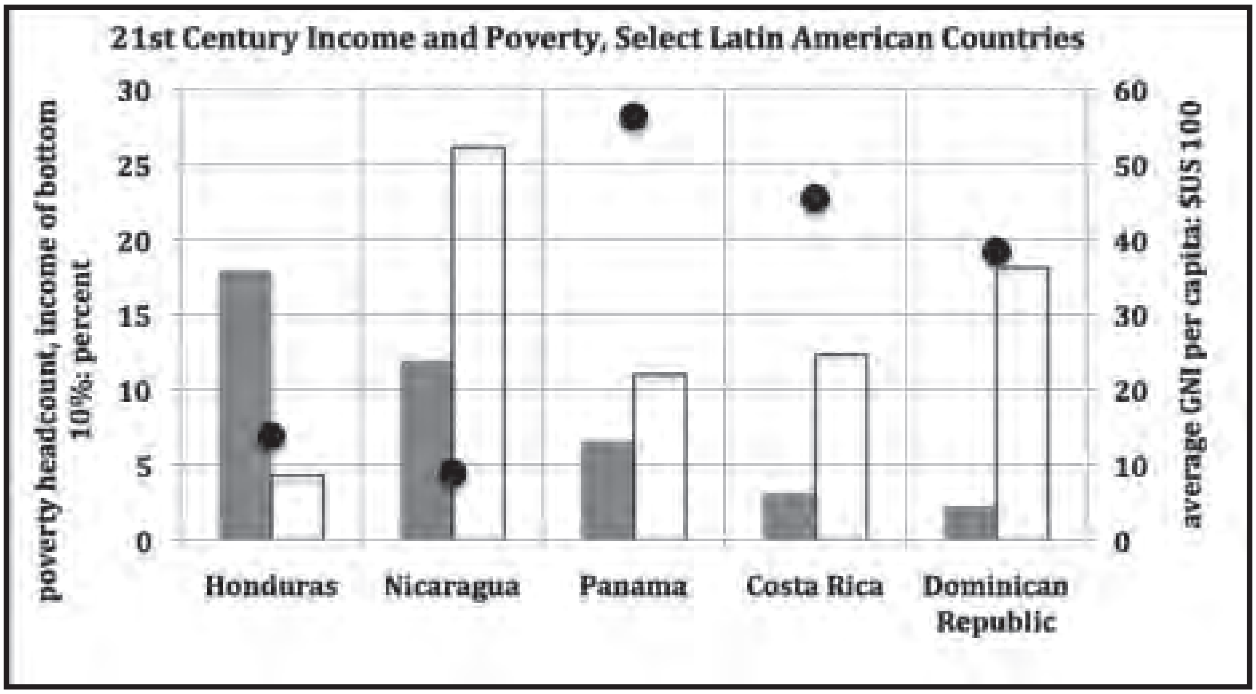
Africa								
	Poverty headcount ratio ($1.25/ day)	Annual GNI ($U.S. billions)	Total population	Income share held by bottom 10 percent (%)	Income per person, bottom 10 percent ($U.S.) (1)	GNI per capita, average ($U.S.)	GNI per capita, average ($U.S. 100)	Income per person, bottom 10% (% of average per capita GNI)
Central African Republic	62.83	0.93	4401051	1.22	25.68	210.47	2.10	12.20
Swaziland	40.63	2.13	1186056	1.66	297.69	1793.32	17.93	16.60
Ethiopia	38.96	18.12	82949541	4.05	88.45	218.39	2.18	40.50
Cape Verde	21.02	0.75	495999	1.88	282.70	1503.72	15.04	18.80
Sudan	19.80	19.17	43551941	2.74	120.61	440.19	4.40	27.40

(1) Hint: Use columns 2 and 4 to calculate the total income held by the poorest 10% of the population; use column 3 to calculate the number of people in 10% of the population; take a ratio. Data source: World Bank



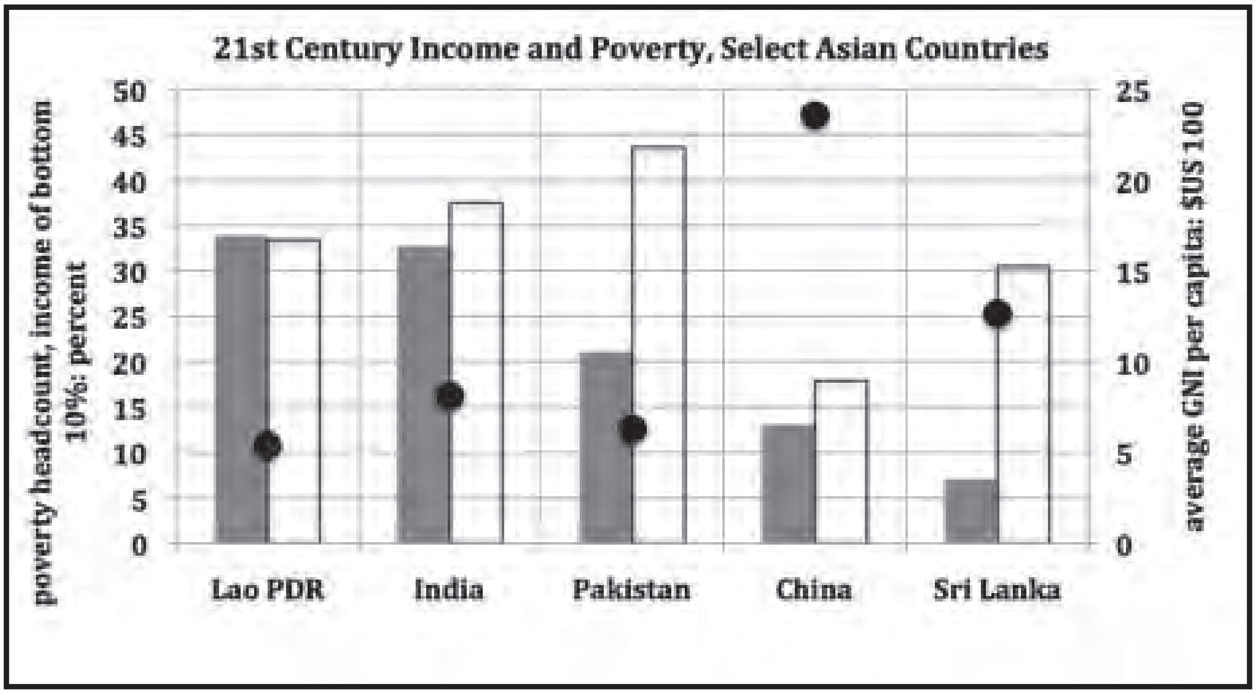
Latin America								
	Poverty headcount ratio ($1.25/ day)	Annual GNI ($U.S. billions)	Total population	Income share held by bottom 10 percent (%)	Income per person, bottom 10 percent ($U.S.) (1)	GNI per capita, average ($U.S.)	GNI per capita, average ($U.S. 100)	Income per person, bottom 10% (% of average per capita GNI)
Honduras	17.92	10.48	7600524	0.43	59.31	1379.22	13.79	4.30
Nicaragua	11.91	5.15	5788163	2.61	232.29	889.99	8.90	26.10
Panama	6.56	19.78	3516820	1.10	618.69	5624.43	56.24	11.00
Costa Rica	3.12	21.17	4658887	1.23	558.84	4543.41	45.43	12.30
Dominican Republic	2.24	38.08	9927320	1.81	694.36	3836.26	38.36	18.10

(1) Hint: Use columns 2 and 4 to calculate the total income held by the poorest 10% of the population; use column 3 to calculate the number of people in 10% of the population; take a ratio. Data source: World Bank



Asia								
	Poverty headcount ratio ($1.25/ day)	Annual GNI ($U.S. billions)	Total population	Income share held by bottom 10 percent (%)	Income per person, bottom 10 percent ($US) (1)	GNI per capita, average ($U.S.)	GNI per capita, average ($U.S. 100)	Income per person, bottom 10% (% of average per capita GNI)
Lao PDR	33.88	3.34	6200894	3.34	179.80	538.32	5.38	33.40
India	32.67	950.65	1170938000	3.75	304.45	811.87	8.12	37.50
Pakistan	21.04	109.19	173593383	4.36	274.23	628.97	6.29	43.60
China	13.06	3152.61	1338299512	1.79	421.67	2355.68	23.56	17.90
Sri Lanka	7.04	26.39	20859949	3.05	385.82	1264.97	12.65	30.50

(1) Hint: Use columns 2 and 4 to calculate the total income held by the poorest 10% of the population; use column 3 to calculate the number of people in 10% of the population; take a ratio. Data source: World Bank



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Lesson Five

Food Trade and Food Aid

Organizing Questions

- How much food do countries and regions obtain through international trade?
- What are the theoretical and practical effects of international agricultural trade on developing countries and food-insecure households?
- What is food aid, and how is food aid classified into different categories and types?
- What trends—in quantity, donors, recipients, and type—have characterized global food aid in the 20th and early 21st centuries?
- How do different types of food aid affect short- and long-term food security?

Introduction

This lesson explores the food security effects of both commercial and noncommercial exchange of food between nations. Students investigate regional and time trends in commercial agricultural trade, and consider a range of factors that may affect the impact of trade on global food security. The lesson also covers trends and issues related to global food aid, including donors and recipients, sourcing and distribution strategies, and factors that determine the effectiveness of various food aid strategies in combating hunger and poverty.

Objectives

In this lesson, students will:

- learn how the dramatic increase in agricultural trade during the late 20th and early 21st centuries affected different global regions;
- learn how the principle of comparative advantage explains the theoretical benefits of open international trade;
- explore potential risks and drawbacks of international trade in agriculture;
- define food aid, classify food aid by commodity, donor, recipient, and modes of procurement and distribution, and explore 20th- and 21st-century food aid trends;
- analyze the food security impacts of food trade and food aid in a relevant case study; and
- work effectively with diverse information sources, including graphs, databases, and news articles.

Materials

- Handout 1, *Introductory Quiz*
- Handout 2, *In-Class News Analysis Exercise*

- Handout 3, *Agricultural Trade—Benefits, Risks, and Regulation*
- Handout 4, *Agricultural Trade Worksheet*
- Handout 5, *Food Aid*
- Handout 6, *Food Aid Worksheet*
- Handout 7, *Quiz—Food Trade and Food Aid*
- Handout 8, *Current Events Case Study*
- Handout 9, *Case Study Presentation Notes*
- Handout 10, *Food Trade and Food Aid Crossword Puzzle*
- (Optional) Projection 1, *Food Aid and Cereal Price*
- Answer Key, *Introductory Quiz*
- Answer Key, *Agricultural Trade Worksheet*
- Answer Key, *Food Aid Worksheet*
- Answer Key, *Quiz—Food Trade and Food Aid*
- Answer Key, *Food Trade and Food Aid Crossword Puzzle*
- (Optional) Answer Key, Projection 1, *Food Aid and Cereal Prices*

Equipment

Internet-ready computers for student research (Day One – optional; Day Three – recommended)

Teacher Preparation

1. Review all handouts, and make the correct number of copies (one per student, unless otherwise indicated).
2. Select news articles for in-class exercise:
   On Day One, students will perform a brief analysis of a news article related to agricultural trade. Depending on time and resources available, instructors may choose to select these articles in advance for distribution in class, or to have students select their own articles from the Internet during class time. If selecting the articles in advance, instructors should perform an Internet news search for "agricultural trade" (or similar keywords) and choose four to six current, in-depth (at least one full page, or about 700 words) articles from credible sources for student analysis. If possible, select articles that represent a range of global regions and perspectives. Print one or two copies of each article to bring to class on Day One (students will be in groups of three or four ; some groups may analyze the same article).
3. Arrange the room for group work throughout the lesson.
4. Prior to Day One (optional) and Day Three (recommended) arrange for access to Internet-ready computers for student research.
5. Optional: For additional background on food trade and food aid, review the following resources (the content of handouts 3 and 5 draws from these sources):
   - Food and Agriculture Organization of the United Nations. 2003. Trade Reforms and Food Security: Conceptualizing the Linkages. Rome: FAO. Chapter 1: Food Security and Trade, an Overview.

Available online from: http://www.fao.org/docrep/005/y4671e/y4671e00.htm

- Lowder, Sarah and Terri Raney. Food Aid: A Primer. ESA Working Paper No. 05-05. 2005. Rome: The Food and Agriculture Organization of the United Nations, Agricultural and Development Economics Division. Available online from: http://www.fao.org/docrep/008/ae878e/ae878e00.htm.

Instructors desiring additional background will find many useful documents on the FAO website (www.fao.org).

Time

The complete lesson requires at least four 50-minute class periods. Options for extending or shortening the lesson are provided in the Extensions and Excerpts section, below.

Procedures Day One

1. (10 minutes) Inform students that they will spend the next several days learning about the effects of food trade and food aid on food security. Distribute one copy of Handout 1, *Introductory Quiz,* to each student. Explain that the quiz is designed to assess their prior knowledge of agricultural trade and to introduce concepts that will be covered in detail later in the lesson; it will not be graded. Give students about five minutes to complete the quiz alone or in pairs, and then spend about five minutes reviewing the correct answers as a class.
2. (30 minutes) Divide the class into groups of three or four students. Distribute one copy of Handout 2, *In-Class News Analysis Exercise,* to each student. Distribute one news article to each group or instruct groups to search online for their own articles as outlined in the handout (see the Teacher Preparation section for details on selecting articles for this exercise). Give the groups about 25 minutes to read their articles and answer the questions on the handout.
3. (10 minutes) Bring the class back together, and have each group give a brief (one minute) report on their article, focusing on summarizing key points and any risks or benefits of agricultural trade that the article mentions.
4. Following the group reports, collect Handout 2 for evaluation. Distribute one copy each of Handout 3, *Agricultural Trade – Benefits, Risks, and Regulation,* to each student. Ask students to read the handout carefully for homework and to bring it with them to the next class period.

Day Two

1. (10 minutes) Ask students to take out Handout 3, and lead a brief class discussion focused on the following prompt:
   In this reading, you learned about the theoretical benefits of agricultural trade, and about several factors that can interfere with the realization of those benefits. Thinking back to yesterday's news

analysis exercise, can you recall any specific examples from your news article that illustrate the theoretical benefits and risks of trade, as described in the reading?

2. (35 minutes) Distribute one copy of Handout 4, *Agricultural Trade Worksheet,* to each student. Divide the class into small groups (two or three students each) and inform students that they will have about half an hour to work on the questions in their group; any unanswered questions should be completed as homework before the end of the lesson. (Note: The worksheet is intended to deepen student understanding of the handout material and includes several complex and challenging questions. To reduce workload, or for less-advanced students, instructors may choose to assign only a some of these questions as required work, leaving the remainder as an extra-credit option.)
3. (5 minutes) Distribute one copy each of Handout 5, *Food Aid,* and Handout 6, *Food Aid Worksheet,* to each student. Ask students to read the handout carefully, and to answer the graph analysis questions on the worksheet, before the next class period. Students should also review the discussion questions and make brief notes on their thoughts, but they do not need to write out formal responses. These questions will be discussed as a class during the next class period. Also inform students that they will have a quiz on the material in Handouts 3 and 5 during the next class period.

Day Three

1. (10 minutes) Distribute one copy of Handout 7, *Quiz, Food Trade and Food Aid,* to each student. Give students about 10 minutes to complete the quiz, and then collect quizzes for evaluation.
2. (10 minutes) Ask students to take out handouts 5 and 6, *Food Aid* and *Food Aid Worksheet*. Divide the class into seven small groups (four or five students per group) and assign each group to one of the discussion questions from Handout 6. Ask groups to spend about 10 minutes discussing their question and formulating a thoughtful response; group members should note key points in the response on their worksheet or on a separate sheet.
3. (10 minutes) Bring the class back together, and ask each group to give a brief (one minute) report on their group's question and response. All students should take notes on the other groups' responses, either on the worksheet or on a separate sheet.
4. (5 minutes) Distribute one copy of Handout 8, *Current Events Case Study,* to each student. Briefly explain the case study assignment. Ask students to read the directions carefully, and take any questions.
5. (15 minutes) Direct students to Internet-ready computers, and give them the remainder of the period to start on the case study. Students should focus on selecting their news article before the end of class; the instructor should circulate among students and verify that each student's selection is appropriate for the assignment.

6. Ask students to complete the case study before the next class period. Remind students of the extra-credit poster option.

Day Four

1. (35 minutes) Divide the class into groups of three or four students, and distribute one copy each of Handout 9, *Case Study Presentation Notes,* and Handout 10, *Food Trade and Food Aid Crossword Puzzle,* to each student. Ask students to take turns summarizing their case studies for their group mates; each student should speak for two or three minutes, while the other group members take notes on the note sheet. When all students have finished speaking, the group should work together to complete the crossword puzzle (each student must complete their own copy).
2. (5 minutes) Ask students who completed posters to hang their posters on a classroom wall.
3. (10–15 minutes) Lead a concluding class discussion of the lesson and case study. The following are suggested questions to focus the discussion:
   - What was the most interesting or surprising thing that you learned from your own case study?
   - What was the most interesting or surprising thing that you learned from a classmate's case study?
   - Based on these case studies, do you think that food trade/food aid is an asset or a liability from a food security perspective? Explain.
   - In general, how do you think that countries could change their trade and aid policies to more effectively promote food security? Explain.
4. At the end of class, collect Handouts 4, 6, 8, and 9 for evaluation. Students should also attach any related work done on separate sheets (e.g., if students took notes on a separate sheet during the group and class discussion of Handout 6, they should be sure to attach their notes to the handout). Collect Handout 10 from students who have completed the puzzle; if any students need additional time, they may submit Handout 10 for evaluation at the beginning of the next class period.

Extensions and Excerpts

Extensions: one optional projection, illustrating an interesting correlation between cereal food aid and cereal prices, is provided with the lesson materials. This projection may be of interest to students who have completed Lesson Three, Part One (Food Price Dynamics). The projection may be shown in class and discussed at any time after students have completed Handouts 5 and 6; the instructor may choose to use time at the end of Day Three for this discussion (leaving students to complete the entire case study as homework, rather than starting in class) or at the end of Day Four, in lieu of the concluding discussion outlined in the standard procedures. Allow about 15 minutes to discuss the questions included on the projection, using the corresponding Answer Key to direct and refine students' comments.

Excerpts: Instructors with less time to devote may shorten the lesson by:

1. Focusing solely on either agricultural trade or food aid. Assign the relevant reading and worksheet (Handouts 3 and 4 for trade, Handouts 5 and 6 for food aid) and adjust the news analysis exercise and case study as necessary (e.g., ask students to select news articles focused on the topic that they have covered in readings). The first half of the grade quiz may be used in classes focusing on trade, the second half in classes focusing on food aid.
2. Omitting the case study, and concluding the lesson with the class discussion of Handout 5 on Day Three.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess Handout 2, *In-Class News Analysis Exercise,* based on:
  - o appropriateness of the group's article selection (if applicable);
  - o completeness the student's responses to the handout questions;
  - o the level of detail, creativity, and logical insight in the student's analysis of the article (identifying relevant benefits and drawbacks of, and barriers to, agricultural trade); and
  - o concision and clarity of the student's summary of the article.
- Assess Handout 4, *Agricultural Trade Worksheet* based on:
  - o completeness and accuracy (use the Answer Key as a guide); and
  - o the level of detail, creativity, and logical insight in the student's responses to open-ended questions. Award points for responses that demonstrate thorough understanding of the material in Handout 3.
- Assess Handout 6, *Food Aid Worksheet*, based on:
  - o completeness and accuracy of the student's responses to the Graph Analysis questions (use the Answer Key as a guide); and
  - o the thoroughness and neatness of the student's notes on the group and class discussion of the reflection questions.
- Assess Handout 7, *Quiz, Food Trade and Food Aid,* based on:
  - o completeness and accuracy (use the Answer Key as a guide); and
  - o the level of detail, creativity, and logical insight in the student's responses to open-ended questions. Award points for responses that demonstrate thorough understanding of the material in Handouts 3 and 5.
- Assess the Current Events Case Study based on:
  - o Content criteria:
    - Did the student select an appropriate article, according to the assignment guidelines?

    - Does the student provide the required information about his or her article (title, date, source, country focus)?
    - Does the student make an effort to provide relevant explanations of all unfamiliar terms and phrases?
    - Does the student accurately record each of the statistics requested?
    - Is information in the assignment presented in an easy-to-follow format? Are responses to analysis questions written in clear language, free of spelling and grammar mistakes?
  - Analysis criteria:
    - Does the student accurately and concisely summarize important points from the article, including relevant benefits and drawbacks or agricultural trade or food aid?
    - Does the student make logical, insightful connections between the statistics and the article content?
    - Does the student provide a logical, insightful assessment of the impact of food trade/food aid on his or her own and other countries' food security status, referring to specific facts and examples from his or her article and statistics?
    - Does the student list at least two thoughtful, relevant questions for further research?
    - Do the student's notes on classmates' presentations reflect thoughtful attention to others' work?
- Assess students' contributions to group work and class discussion based on:
  - accuracy and appropriateness of contributions;
  - clear and succinct statement of comments, questions, and answers;
  - attention to other students' questions and ideas;
  - Ability to follow and promote lively, productive discussion;
  - open-mindedness and respect for other students' backgrounds and opinions;
  - willingness and ability to compromise and incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
  - willingness and ability to express confusion and request clarification from other students and the instructor.

Introductory Quiz

1. In 2010, the total volume of global trade in agricultural products was:
   a. Less than one-half of the volume in 1960
   b. About one-half of the volume in 1960
   c. About the same as the volume in 1960
   d. About twice the volume in 1960
   e. More than twice the volume in 1960

2. Which of the following regions <u>imported</u> more food than they <u>exported</u> in 2010? Circle all that apply:
   Africa Asia Europe North America South America

3. True or false: Although its actions affect developing countries, the World Trade Organization has no representation from developing-country governments.
   True False

4. True or false: The term "food aid" refers only to no-cost donations of food intended to improve food security in the recipient country.
   True False

5. True or false: Food aid donations always consist of crops grown in the donor country.
   True False

6. Which region received the most food aid in 2010?
   Africa Asia Europe North America South America

7. True or false: Most food aid donations are in the form of wheat, maize, and other grains.
   True False

In-Class News Analysis Exercise

Directions: Your teacher will either assign you an article on the topic of agricultural trade or instruct you to find an appropriate article using an online news search. If you are asked to select your own article, be sure to choose an in-depth piece (at least one or two printed pages in length; a news or feature story rather than an editorial or sidebar) from a credible source (i.e., not a personal blog, political interest group, etc.).

Read your article carefully, and work as a group to answer the questions below. Group members should write their answers on separate sheets.

Use a separate sheet for your answers

Article title:

Article source:

Article date:

What country or countries and product or products, if any, are specifically mentioned in the article?

Describe any **benefits** (potential or realized) of agricultural trade mentioned in the article.

Describe any **risks** or **drawbacks** (potential or realized) of agricultural trade mentioned in the article.

Describe any **barriers** (environmental, social, economic, political, etc) to agricultural trade mentioned in the article.

Summarize the central point of the article in one or two sentences.

Agricultural Trade—Benefits, Risks, and Regulation

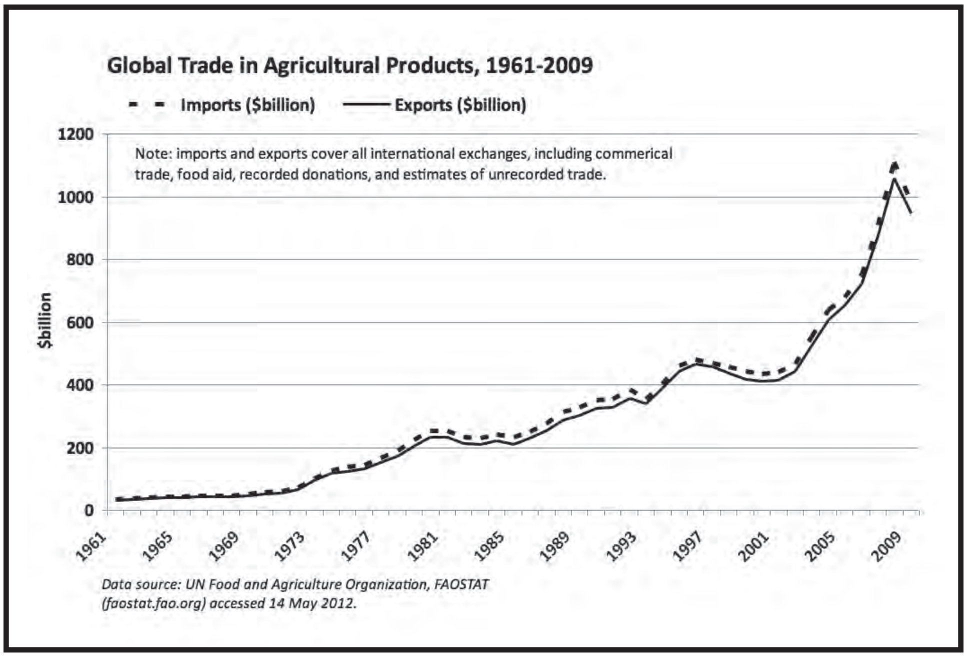
In Lesson Two, you learned that countries and regions differ in their capacities to grow food crops. Physical variables, such as weather, climate, and soil type, make some areas unsuitable for crop production. Social and economic variables—most notably, household and national poverty—often undermine farmers' access to fertilizers, pesticides, irrigation systems, and other resources that could help them overcome environmental obstacles. Even in affluent areas, environmental constraints may be insurmountable. For example, a country with a high population density may simply lack the land area to support extensive agricultural production.

On the other hand, some countries possess an abundance of resources to support agricultural production and are able to produce much more food than their own citizens will consume. By transferring excess production to countries that lack these resources—either through direct sales or through programs that distribute food donations in low-income countries—high-producing countries open profitable new markets for their own farmers, and help improve food security around the world.

International trade in agricultural products has occurred for centuries, but the volume and importance of trade increased dramatically in the 20th century, as a result of steady improvement in global transportation and communication networks. The chart below shows the growth in total imports and exports of agricultural products (expressed in terms of the dollar value of products exchanged) from 1960 to 2009.

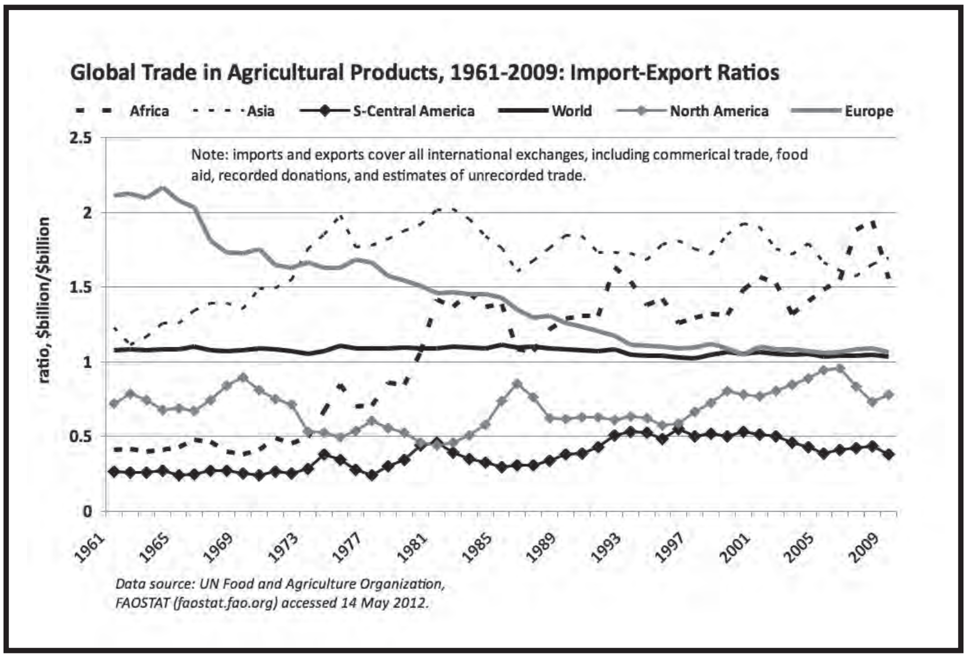
imports—externally produced (foreign) goods moved into a country (via commercial sale or donation)

exports—domestically produced goods moved out of a country (via commercial sale or donation to other countries)



As the figure illustrates, the total value of these exchanges in 2009 was well over 10 times the total value in 1961.

However, the growth in trade has not affected all regions equally. Some areas have increased their imports, relying more and more on the production of other countries to feed their own citizens; others have increased exports, taking advantage of the opportunity to meet importing countries' demands. The chart below shows changes in the ratio of food import value to food export value, from 1960 to 2009, for several global regions. Note that the ratio for the world as a whole remains close to one—barring losses in transport or errors in data collection, products that are exported from one country must be imported to another. Also note that these exchanges include noncommercial transfers, such as food aid and other donations.



The import-to-export ratio in North and South America remained fairly steady during this period and is less than one—these countries export more food (by value) than they import. In Europe, the ratio fell from more than two to just over one in the latter half of the 20th century, indicating that European countries have gone from importing twice as much food value as they export, to importing and exporting approximately the same value. In Africa and Asia, however, imports have increased relative to exports, with 21st century ratios hovering around 1.75.

Is a high import-export ratio a bad thing? Not necessarily. As discussed at the beginning of this handout, some countries are physically unable to produce enough food for domestic consumption—their agricultural output may be limited by climate, soil nutrient status, or available land area. It is much more efficient for these countries to engage in other productive activities—mineral extraction, manufacturing, tourist services, etc.—and to trade the output of those activities for food, than it is for them to exhaust resources such as money and labor in an effort to force agricultural production in an inhospitable environment. Countries that can produce large quantities of food also benefit from this arrangement, as they are able to trade their surplus production for other goods and services that they may not be able to produce as efficiently. To an economist, this mutually beneficial trade relationship would illustrate the principle of comparative advantage (see Box 1).

In theory, open trade based on the principle of comparative advantage always leaves at least one country better off, and never leaves either country worse off, than before the trade. In practice, however, other factors frequently undermine the benefits of trade, especially for lower-income countries. These factors include:

- **Supports and subsidies**

Many countries artificially lower production costs for certain goods by providing a subsidy to producers. For example, a government may offer a sum of money for every unit of output, provide free or reduced-cost inputs, or exempt production costs from government taxation. Producers increase their output as a result of a subsidy, and lower their prices to reflect their reduced production costs. With domestic supply rising and prices falling, imports from other countries will not be as attractive, even if those countries would otherwise have had the comparative advantage in production. In fact, the subsidy-granting country may end up exporting surplus production, hurting the foreign producer by forcing them to compete with the artificially low price.

- **Emerging industries**

Even if a country's physical resources are well suited to the production of a good, production costs will be quite high if workers have just begun developing relevant skills and technology. In this case, the country *could* have comparative advantage, but domestic production will need some time to "get off the ground." Imports from other countries can impede that process if foreign producers face lower production costs; lower production costs translate to lower prices, and consumers will naturally choose the cheaper imported goods, drawing money away from domestic producers when they most need the resources to grow. Some countries institute subsidies to help emerging domestic industries compete effectively with international imports; others may choose to restrict imports by imposing an import tariff or quota.

- **Flexibility**

Suppose that Country A begins to import rice, which it had previously produced domestically, from Country B. If Country B has a comparative advantage in rice production, Country A will reduce its production of rice, and employment in rice farming in Country A will fall. In theory, the citizens of Country A who are displaced from rice farming should find work producing other goods—goods in which Country A does have a comparative advantage, and which they can export for a profit. In

comparative advantage—an economic principle stating that countries (or businesses, individuals, etc.) maximize benefits by producing only the goods and services that they can produce most efficiently relative to all other goods and services, and trading those goods and services with others to meet their needs. Comparative advantage explains why all countries, even those capable of meeting their own needs entirely through domestic production, can benefit from international trade

subsidy—a direct or indirect payment, usually granted by a government, intended to promote economic activities deemed to be beneficial to society. For example, governments often subsidize agricultural production (through direct payments, tax breaks, etc., given to farmers) to raise domestic food production and improve domestic farmers' competitiveness in the international food market

industry—collective term for all economic activity (production and consumption) of a particular type of good or service (e.g., food, textiles, insurance, education)

tariff—a tax levied on traded goods. Countries impose tariffs on agricultural imports and exports for a variety of reasons; for example, an import tariff would raise the cost of imports, making it easier for domestic producers to compete with foreign products; an export tariff (levied on producers who sell outside the country) would reduce the attractiveness or exporting, keeping more food in the country to protect domestic food security

quota—a mandated maximum or minimum amount; for example, and import quota usually specifies the maximum quantity of a particular good that a country will import. Import quotas may be instituted to protect domestic producers from competition from foreign imports

practice, however, rice farmers are unlikely to have the necessary skills to switch industries on short notice. Any increase in Country A's output of other goods will come as a result of increased efficiency (new technology, etc.), not by hiring unskilled labor from the shrinking rice industry. Unless rice farmers can be quickly retrained for other work, overall unemployment in Country A will rise, and poverty and food insecurity may increase.

- **Negotiating power**

If you read through the numerical example of comparative advantage in Box 1, you will note that Country A and Country B could settle on a trading price anywhere between one-quarter and one-half a tonne of grapes per tonne of corn. The former price would be preferable to Country A, while the latter would be more appealing to Country B. The actual price will depend on each country's negotiating power, which will often depend in turn on the country's wealth and access to resources. Thus, poorer countries may sometimes find themselves forced to accept trade deals that offer only a very small net benefit.

- **Frictional costs and market access**

The principle of comparative advantage assumes that trades are "frictionless," i.e., that the actual exchange of goods occurs with no cost to either country. In reality, of course, the exchange does have a cost—goods must be packed, stored, transported, and usually inspected upon arrival. For developing country producers, these costs may be very high; for example, they may not have easy access to transportation hubs such as seaports and airports. If the frictional costs of trade are greater than the benefits, the trade will not take place, and potential gains from the comparative advantage in production will not be realized.

- **Within-country distribution of benefits**

externality—an "external" cost or benefit of a product that is not reflected in the market (i.e., sale or purchase) price of the product. For example, the public health costs of secondhand smoke are an externality of cigarette production and consumption. Externalities can also be positive; for example, immunization against disease benefits not only the individual who pays for the immunization, but also others with whom the individual comes into regular contact, as the immunized individual is no longer a potential carrier of the disease

A trade that benefits the country as a whole does not necessarily benefit the country's neediest citizens, or even its average citizens. For example, suppose that in Country Z, a small, elite class produces high-value widgets, while the rest of the population works in low-value agriculture. The country exports many widgets at a very high price; however, the elite class jealously hoards the earnings from these exports, using them to import luxury food products (i.e., the elite class does not purchase food from the lower class' farms; if they did, benefits from the export earnings could potentially trickle down to the poor farmers). In this case, Country Z is better off from trade only in the sense that the elite class is better off. They are not better off in terms of poverty, hunger, unemployment, or other key indicators of social welfare.

- **Social and environmental externalities**

Countries achieve economic gains from trade when their economic costs of production differ—e.g., a country can save money by importing a product that is expensive to produce domestically. In some cases, however, the economic cost of production may be only a small fraction of the full cost. For example, the economic costs of crop production may be lower in a country that permits the use of toxic pesticides, but the country will also incur long-term losses as pesticide pollution impacts human health and water and soil quality. The lax environmental regulations give this country a comparative advantage in crop production, but if domestic farmers increase their production to exploit trade opportunities, the total environmental and health losses may ultimately outweigh the economic gains from trade.

Externalities become a particular concern when international corporations move production to developing countries in order to take advantage of looser environmental and social regulation (e.g., minimum wages). The developing country may benefit in the short term from increased income and employment opportunities, but in the long term, it will bear the environmental and social costs of developed countries' consumption.

- **Food aid**

The effects of food donations may be very different from those of commercial food imports. Food aid is an essential tool in acute food security crises, but long-term reliance on international donations may prevent recipient countries from achieving food self-reliance—either by developing the capacity to produce sufficient food on domestic farms (i.e., food self-sufficiency) or by developing comparative advantage in the production of other goods and services that they can trade for food in commercial markets. We will look at food aid trends and consequences in greater detail in the second part of this lesson.

self-reliance (food—a country is food self-reliant if domestic firms, individuals, and the government can purchase enough food in commercial markets to meet domestic consumption demands (compensating for any shortfall in domestic food production or any deficit in food self-sufficiency).

self-sufficiency (food—a country is food self-sufficient if domestic farmers produce enough food to meet domestic consumption demands.

Is the increase in international agricultural trade good for developing countries? Do country-to-country exchanges of food products help to improve food security? The answer, as you may already have concluded from the discussion above, is "it depends." In the next exercise, you will develop a brief profile of agricultural trade in a specific country. Keep the factors above in mind as you work; after completing your profile, you will be asked to assess the costs and benefits of agricultural trade in your country.

Source: Food and Agriculture Organization of the United Nations. 2003. Trade Reforms and Food Security: Conceptualizing the Linkages. Rome: FAO. Chapter 1: Food Security and Trade, an Overview.

Comparative Advantage

The following example illustrates the principle of comparative advantage:

Maize and most other staple grains grow well in a wide range of environments, but specialty crops such as fruits and nuts have more restricted growing regions. Suppose that the climate of Country A is uniquely suited to growing grapes. Country A has an **absolute advantage** in producing grapes—its environment makes production absolutely more efficient. It may also have an absolute advantage in producing staple grains; however, it would have to sacrifice land, labor, fertilizer, and other resources that could be devoted to grape production in order to do so.

By contrast, Country B, which can only produce staple grains, loses little by devoting its energies to the production of staple grains. Country B therefore has a comparative advantage in staple grain production. If each country produces the crop in which it has comparative advantage, the countries can trade with each other to their mutual benefit.

We can clarify this example by attaching some numbers. Suppose that Country A can produce six tonnes of corn, or three tonnes of grapes, on one hectare of land. Meanwhile, Country B can produce four tonnes of corn or one tonne of grapes per hectare. Country A is three times as efficient at grape production but only 1.5 times as efficient at corn production.

If Country A produces only grapes, it will be willing to trade up to one tonne of grapes for two tonnes of corn (the most corn that it could produce if it simply transferred one hectare of land from grape to corn production, since its corn production is twice as land-efficient). Country B, however, will be willing to part with two tonnes of corn for as little as a half-tonne of grapes, since it could produce only a half-tonne of grapes on the land required to produce two tonnes of corn. If the countries trade at a price between one-half and one tonne of grapes per two tonnes of corn, both will do better than they each could have done alone.

This example demonstrates that even advanced, industrialized countries can benefit from trade with lower productivity regions. Trade allows countries to focus their productive resources in areas where they can excel, thus maximizing total production, total income, and the options available to them through trade.

The principle extends to industries beyond agriculture; for example, countries whose climates are only marginally suited to agriculture will benefit from developing other resources—mineral and petroleum reserves, productive fisheries, factories and manufacturing capacity, tourist attractions, an educated labor force, etc.—and producing other goods and services to trade for food. Those trades will also benefit countries with highly productive agricultural sectors, as they will receive a range of goods and services in trade without sacrificing their crop output.

The World Trade Organization

The World Trade Organization (WTO) helps countries negotiate fair rules and policies for international trade. As of 2012, the WTO represented over 150 member nations, which collectively accounted for over 95 percent of global trade.

In addition to its role as a forum for international trade negotiations, the WTO reviews national trade policies and helps countries resolve disputes related to trade. The organization's overarching goal is to remove national tariffs, quotas, and subsidies that prevent or distort free and open trade. The theory of comparative advantage states that removal of these barriers should lead to gains for both countries; however, national governments are often reluctant for political reasons to dismantle trade barriers that give advantages to domestic producers. Structured, well-facilitated negotiation—which the WTO aims to provide—can help trading countries develop mutually acceptable plans for trade liberalization.

About three-quarters of the WTO member countries are considered "developing countries" by international standards. WTO agreements recognize the risks that trade liberalization presents for some of these countries, and WTO agreements often make special provisions for developing nations whose domestic industries might be harmed by international competition. Developing nations are usually given extra time to implement agreements, and can receive training and support in trade policy planning through WTO programs.

During the 1990s, WTO negotiations focused on reducing barriers to trade in telecommunications, technology, and financial services. At the beginning of the 21st century, the WTO turned its attention to agriculture. The so-called Doha Round of negotiations (named for the city of Doha, Qatar, where negotiations launched in 2001) has focused on improving the trade prospects of developing countries, largely through policy reforms related to agricultural production and trade.

Source: World Trade Organization,
"The WTO in Brief," http://wto.org/english/thewto_e/whatis_e/inbrief_e/inbr00_e.htm, accessed 21 May 2012.

Agricultural Trade Worksheet

Instructions: Carefully review Handout 3, *Agricultural Trade—Benefits and Risks, and Regulations*, and use the information in the handout to answer the questions below. You may work alone or with a partner, but be sure to provide a thorough response to each question on your own worksheet. Your teacher will collect the worksheets for evaluation at the end of the lesson.

Briefly define the following terms:

- Food self-sufficiency
- Food self-reliance
- Quota
- Tariff
- Subsidy
- Externality

During the 20th century, the value and importance of international trade in agricultural products ________________ (increased / decreased / remained constant).

In 2009, which of the following regions had an agricultural import-export ratio of greater than one (i.e., import value greater than export value)? Select all that apply.

a. Africa
b. Asia
c. Europe
d. North America
a. South America

Country A produces corn, and Country B produces soybeans. In an effort to increase domestic food production, Country A decides to offer tax breaks for farmers who plant an additional soy crop between rotations of corn. How might the tax break affect farmers in Country B? Explain your answer, including any assumptions you make.

Scientists in Country M have just confirmed that the country's soil nutrient profile is uniquely suited to the production of citrus fruit. Country M currently imports citrus from Country C but would now like to exploit its natural advantage to meet domestic demand and become an exporter in its own right. However, farmers in Country M have never grown citrus and will need time to build new infrastructure and adjust their practices.

a. What actions might the government of Country M take to support growth of the citrus industry? List as many options as you can think of.

b. Which, if any, of the actions described above would you advise the government to take? Explain, focusing on consequences in both the short and long term, internationally as well as domestically.

c. Describe a scenario in which frictional costs of trade might deter a country from exporting a product in which it has a strong comparative advantage in production.

d. Describe a scenario in which a social or environmental externality would undermine gains from trade.

In Country R, rice farming is the only economic activity, and rice is the major food staple. Rice production is labor-intensive, and yields are low. In Country Q, large industrial farms produce rice in large quantities at little cost. Country Q also produces a variety of other food products.

a. Which country has the comparative advantage in rice production? Explain.

b. If Country R begins importing rice from Country Q, will food security in Country R improve? Explain.

c. If Country Q donates rice to Country R through an international food aid program, will food security in Country R improve in the short run? In the long run? Explain.

d. How do you think that Country Q could best help to improve food security in Country R?

In Country X, farmers require 10 kilograms of fertilizer to produce 1 tonne of wheat and 5 kilograms of fertilizer to produce 1 tonne of maize. In Country Y, farmers require 3 kilograms of fertilizer to produce 1 tonne of wheat and 2 kilograms of fertilizer to produce 1 tonne of maize.

a. Which country has the comparative advantage in maize production?

b. Suppose each country has access to 90 kilograms of fertilizer. According to the principle of comparative advantage, how much of each crop should Country X and Country Y respectively produce?

c. If the two countries produce the quantities you found in (b):
   i. Suggest a trade that would make Country X better off, and Country Y no worse off.

   ii. Suggest a trade that would make Country Y better off, and Country X no worse off.

   iii. Which trade do you think is more likely to take place? Why?

List two major goals of the World Trade Organization:

FOOD AID

The term "food aid" refers to food-based humanitarian interventions, which can take many different forms. For example, food aid may be delivered in regular installments as a part of an ongoing program, or on a one-time basis in response to a humanitarian crisis or natural disaster. Aid deliveries may consist of grains, oils, or dairy products; they may target different demographic groups within any of several dozen recipient countries. Donors may choose to export their own domestic production as food aid, or to purchase food in another country for subsequent donation. Food aid is usually intended to improve food security in the recipient country; however, some food aid interventions are more focused on supporting agriculture and other food-related industries in donor countries. Although all of these actions fall under accepted definitions of "food aid," each has a slightly different impact on international food security.

In the remainder of this handout, you will learn about several different ways of classifying food aid. Each classification is followed by a few questions for review, extension, and discussion. On the last pages of the handout, you will find several graphs showing trends in food aid over the past several decades; you will need to refer to the graphs as you work through the questions.

Classifying food aid by commodity

Food aid deliveries consist almost entirely of cereals—primarily wheat, maize, and rice. When non-cereal goods are included, vegetable oils and milk powders are the most common.

Classifying food aid by donor

The United States is the world's most important food aid donor. Each year, the U.S. accounts for about 50 to 60 percent (by weight) of global cereal food aid deliveries. Monetary donations from the United States also make up about 60 percent of the budget of the United Nations' food aid agency, the World Food Programme. Other major food aid donors include Canada, Japan, Australia, and the countries of the European Union. Middle-income countries such as China and India are also beginning to emerge as important contributors to global food aid deliveries.

World Food Programme (WFP)— the United Nations' frontline food aid agency. The WFP coordinates delivery of international food aid in hunger crises, and manages a range of food-related development initiatives in the developing world

Classifying food aid by recipient (region)

The developing countries of Africa and Asia receive the majority of the world's food aid; in 2006, Africa received about 60 percent, and Asia received about 35 percent, of total cereal food aid shipments. Of the remaining 5 to 6 percent, most goes to Latin America, and a very small share goes to Eastern European countries.

According to the U.N. Food and Agriculture Organization, 138 countries received food aid during the period 1988–2003. Of those countries, 48 were in sub-Saharan Africa, 27 were in Asia, 31 were in Latin America, 17 were in Eastern Europe, and 15 were in North Africa and the Middle East. The top 10 food aid recipients were Ethiopia, Bangladesh, the Russian Federation, North Korea, Egypt, Mozambique, India, Sudan, Indonesia, and Peru.

Classifying food aid by mode of delivery

The "mode of delivery" refers to the conditions under which food aid is granted to a country. Most donors use one of the following three delivery modes:

- Program delivery (program food aid)
  Program food aid refers to food sold by the government of a donor country at a concessional (discounted) price (or sometimes given free), purchased or received by the government of the recipient country, and resold by that government to the recipient country's population. Although program food aid does expand food supply in the recipient country, its primary impact may not be to improve food security; some program food aid is conducted in order to generate revenue for the recipient government, help the donor country dispose of production surpluses, or allow the donor country to expand its influence in international food markets.
- Project delivery (project food aid)
  Project food aid refers to food distributed as a part of ongoing efforts to promote food security, economic development, and rural development in poor countries. Project food aid may be distributed for free, granted to communities or individuals in exchange for work, or used to support participation in other development-promoting activities (e.g., school lunch programs). Most project food aid is distributed by nongovernmental organizations, which receive donations from private businesses and individuals as well as from national governments.
  Project food aid may also refer to the sale of food to generate funds for other development programs. This process, known as monetization of food aid, increased significantly between the 1980s and the first decade of the 21st century. As of 2003, about one-third of all project food aid was monetized.
- Emergency delivery (emergency food aid)
  Emergency food aid refers to the distribution of food in response to any crisis that threatens food security—such as a war, natural disaster, widespread crop failure, or economic collapse. Emergency food aid may be distributed on one-time basis or may overlap with ongoing project food aid.
  In the past, emergency food aid has almost always been distributed for free; around the early 21st century, however, some donors began to sell a share of emergency food aid at a discounted price, as commonly seen in program food aid. About 10 percent of total food aid (program, project, and emergency) is now sold at some price; the remaining 90 percent is "donated" in a strict sense.

monetization (of food aid)—the sale of donated food in a (usually in the aid-receiving, e.g., developing and/or food insecure, country) to generate funds for other development programs

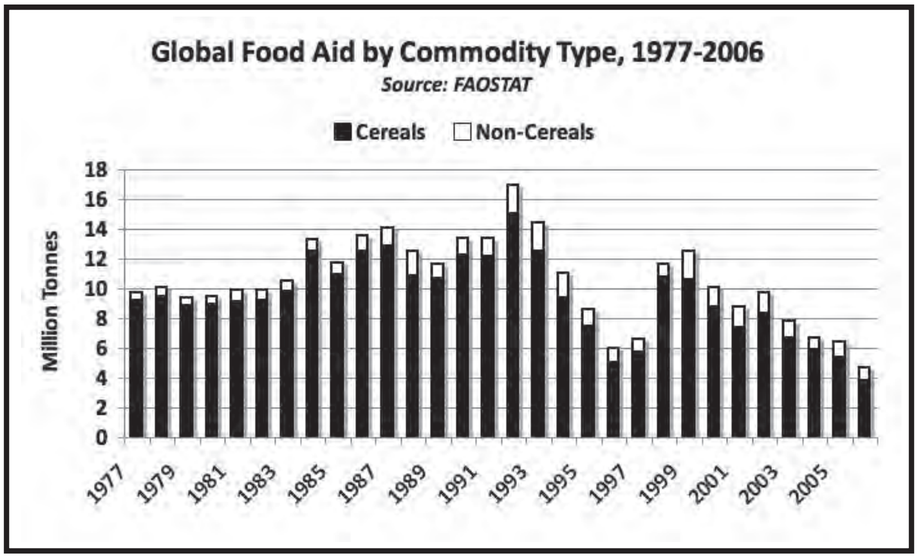
Classifying food aid by mode of procurement

The "mode of procurement" refers to the source of food distributed as food aid. In most cases, there are three possible modes of procurement: direct transfers, local purchases, and triangular purchases.

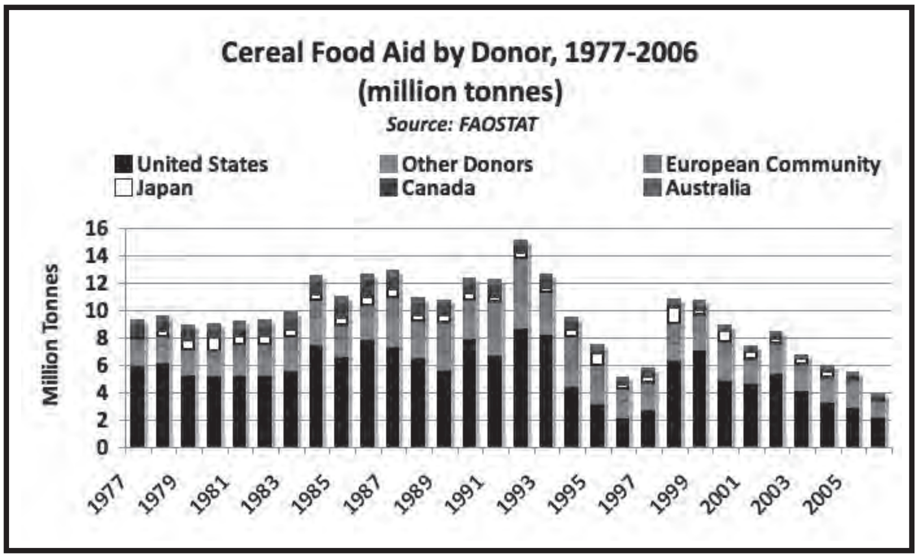
- Direct transfer: A donor country ships its own domestically produced food to a recipient country.
- Local purchase: A donor country uses food aid funds to purchase food from farmers in a recipient country; the locally purchased food is then redistributed to food insecure communities in the recipient country.
- Triangular purchase (sometimes called a Triangular Food Aid Transaction, or TFAT): A donor country uses food aid funds to purchase food from farmers in a third country; the purchased food is then distributed to food insecure communities in the recipient country. The donor country in a TFAT is usually a high-income country such as the United States, but the food may be sourced from a developing middle-income country (e.g., China or Brazil).

Source: Lowder, Sarah and Terri Raney. Food Aid: A Primer. ESA Working Paper No. 05-05. 2005. Rome: The Food and Agriculture Organization of the United Nations, Agricultural and Development Economics Division.

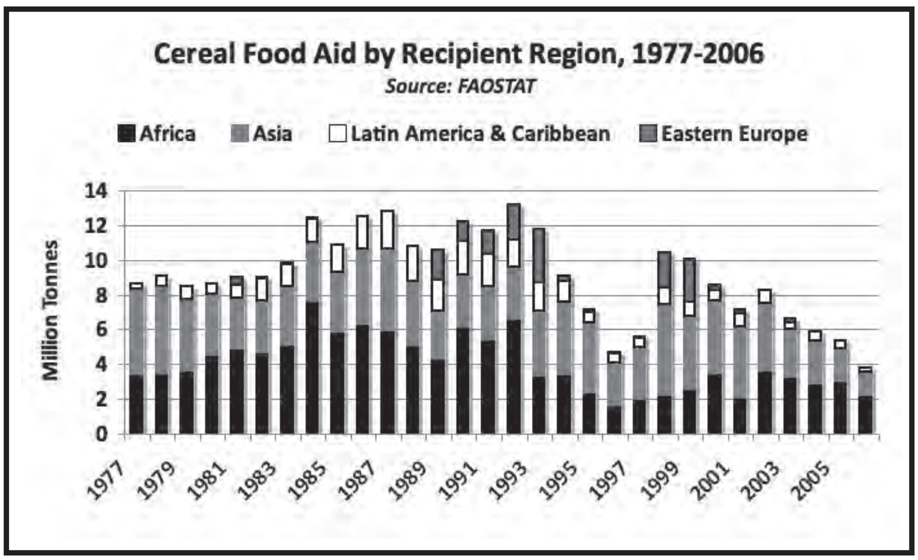
Graph 1



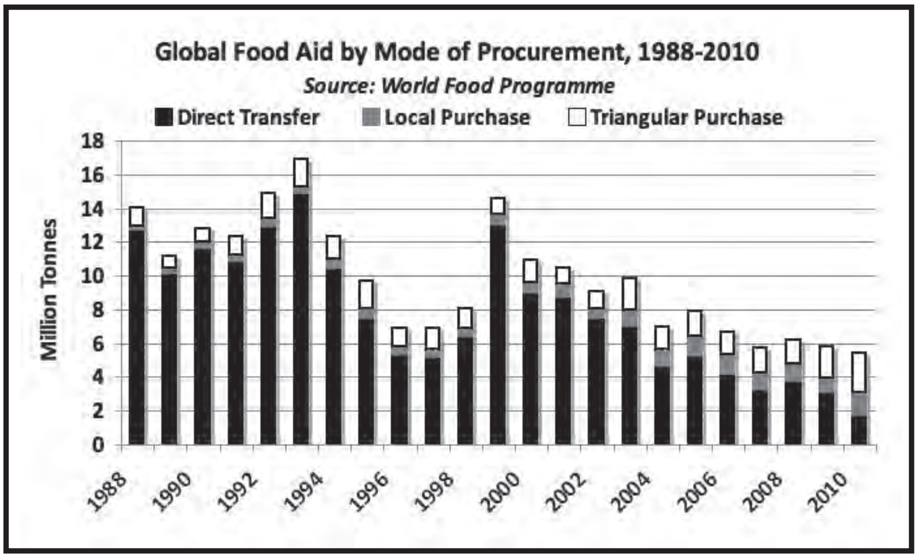
Graph 2



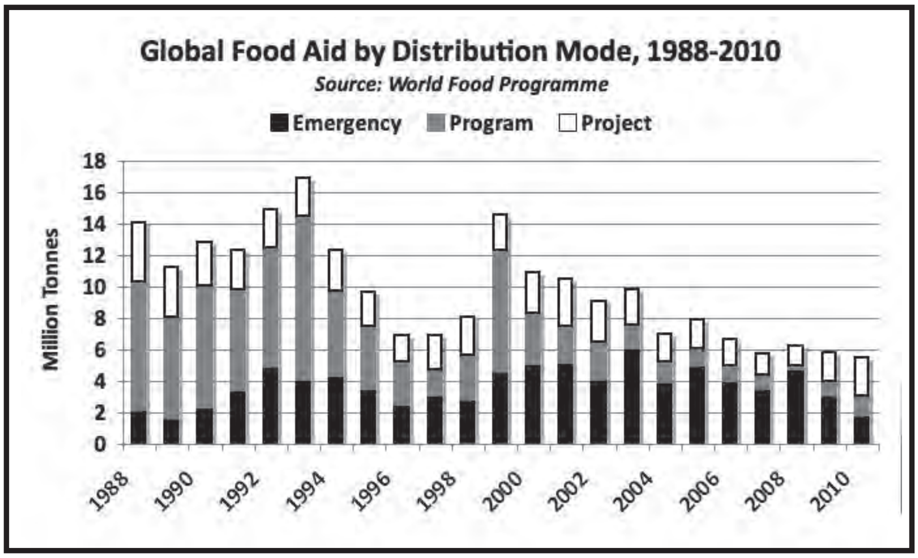
Graph 3



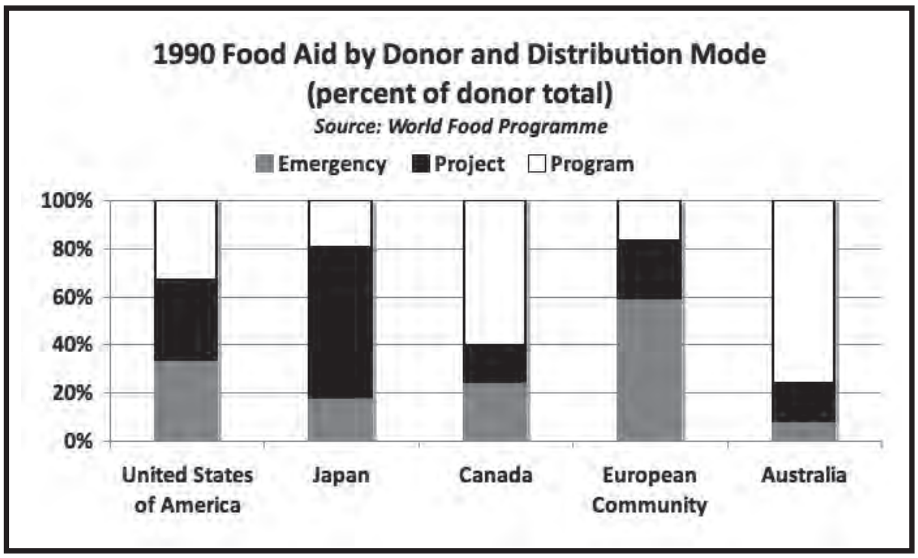
Graph 4



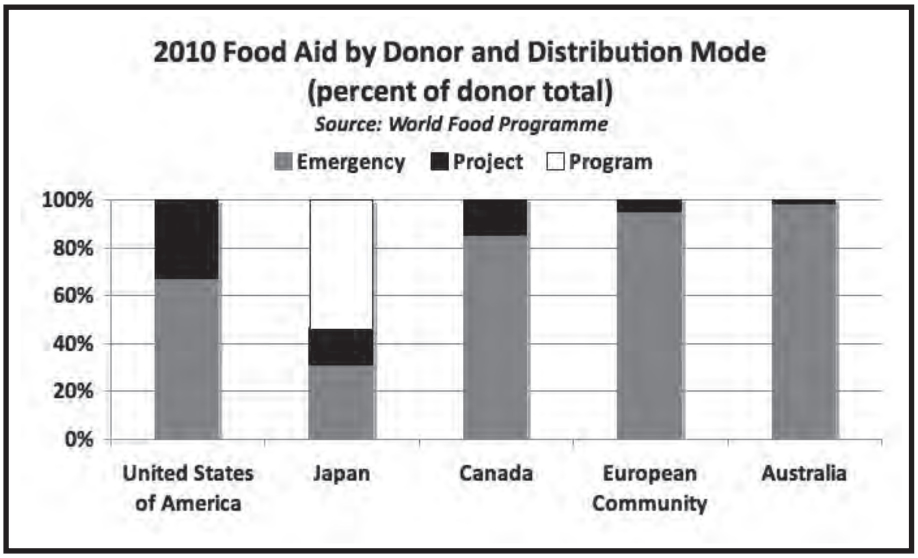
Graph 5



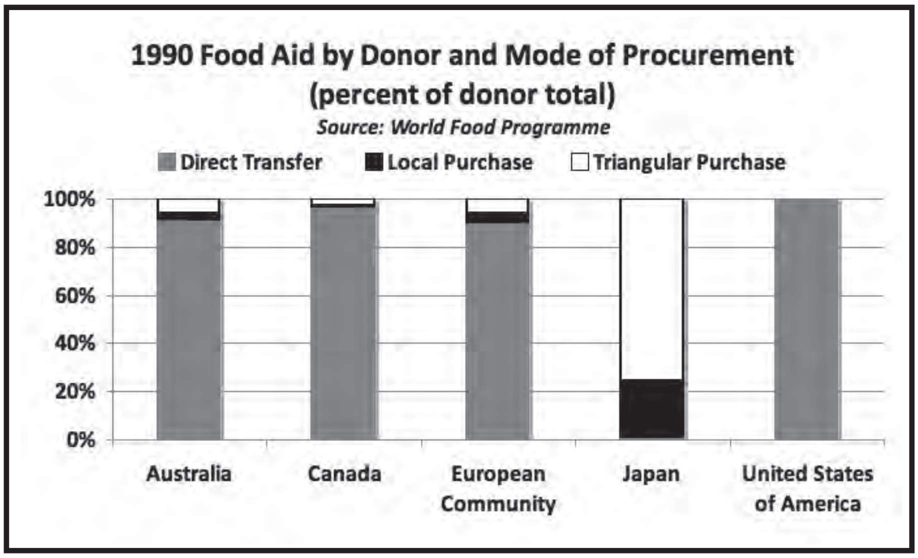
Graph 6



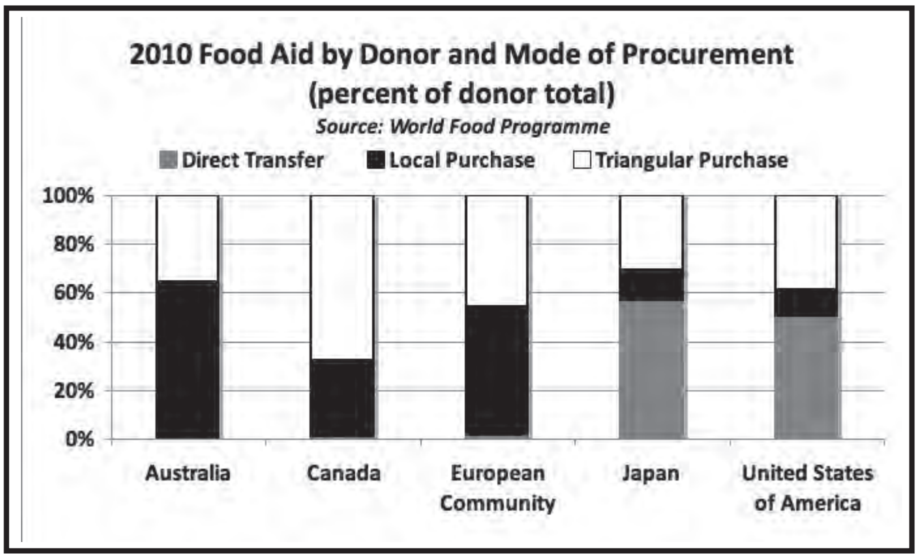
Graph 7



Graph 8



Graph 9



Food Aid Worksheet

Directions: Respond to the following questions as you read each section of Handout 5, *Food Aid*. Be sure to carefully study the graphs associated with each section and question. Several questions for reflection and discussion are provided at the end of the worksheet; you should review these questions, make brief notes, and be prepared to comment on them in class, but you do not need to write formal responses.

Graph Analysis Questions:

Classifying Food Aid by Commodity:

1. (Graph 1) Describe changes in the total annual quantity of food aid delivered between 1977 and 2006. In what years were deliveries the highest? The lowest?

2. (Graph 1) Describe changes in the total annual quantity of non-cereal food aid deliveries between 1977 and 2006. In what years were non-cereal deliveries the highest? The lowest? Describe any apparent relationship between total deliveries and non-cereal deliveries.

Classifying Food Aid by Donor

3. (Graph 2)

a. Describe how the total annual quantity of cereal food aid donated by the United States changed between 1977 and 2006.

b. Describe how United States' share of total cereal food aid donations changed between 1977 and 2006.

Classifying Food Aid by Recipient

4. (Graph 3) For the period 1977–2006 (shown on the graph), fill in the blanks and explain each of the following trends:

a. The ____________________ (increase/decrease) in food aid shipments to Asia

Explain:

b. The ____________________ (increase/decrease) in food aid shipments to Africa

Explain:

c. (Bonus) Explain the spike in food aid shipments to Eastern Europe in the early 1990s:

Classifying Food Aid by Mode of Delivery

5. (Graph 4) Describe how the balance of program, project, and emergency food aid changed between 1988 and 2010. Which delivery mode(s) has/have become more common? Which has/have become less common?

6. (Graphs 6-7) Of the major donors shown in Graph 7 (2010), which country most heavily favored each of the following food aid delivery modes (i.e., delivered the largest share of its food aid donations via the indicated delivery mode)?
   a. Program:
   b. Project:
   c. Emergency:

   If these rankings changed between 1990 and 2010, describe the change:

Classifying Food Aid by Mode of Procurement

7. (Graph 5) Describe how the balance of direct food aid transfers, local food aid purchases, and triangular food aid purchases changed between 1988 and 2010. Which mode(s) of procurement has/have become more common? Which has/have become less common?

8. (Graphs 8 and 9) Of the major donors shown in Graph 9 (2010), which country most heavily favored each of the following food aid procurement modes (i.e., delivered the largest share of its food aid donations via the indicated procurement mode)?
   a. Direct transfers:
   b. Local purchases:
   c. Triangular purchases:

   If these rankings changed between 1990 and 2010, describe the change.

Questions for Reflection and Discussion:

1. Do you think that cereal and non-cereal deliveries have different effects on food security? Why (or why not)?

2. What factors might contribute to year-to-year variation in the total quantity of food aid delivered? In the quantity of non-cereal food aid delivered? Explain.

3. From a food security perspective, do you think that it is it better to have food aid donations coming mostly from one country or to have many countries making smaller donations? Explain your answer.

4. What factors do you think may have contributed to the changing balance of program, project, and emergency food aid between 1988 and 2010? Explain.

5. Of the three main food aid distribution modes—program, project, and emergency—which do you think is the least likely to improve food security? Which do you think is most likely to improve food security? Thoroughly explain your response.

6. What factors do you think may have contributed to the changing balance of direct food aid transfers, local food aid purchases, and triangular food aid purchases between 1988 and 2010? Explain.

7. Of the three main food aid procurement modes—direct transfers, local purchases, and triangular purchases—which do you think is the least likely to improve food security? Which do you think is most likely to improve food security? Thoroughly explain your response.

Quiz—Food Trade and Food Aid

1. For each of the following regions, describe important changes in the volume of agricultural trade (imports, exports, total) during the period 1960–2009:
   a. World

   b. Europe

   c. South America

   d. Africa

   e. Asia

2. Which of the following illustrates the principle of comparative advantage?
   a. By hiring a staff of skilled diplomats, the wealthy government of Country A is able to negotiate a favorable trade deal with Country B.
   b. In the midst of a prolonged drought, Country A chooses not to install expensive irrigation equipment; instead, farmers switch to growing drought-tolerant crops, which they trade for tropical plants grown in Country B.
   c. Country B learns that Country C is exporting corn for a lower price than Country A and reduces import costs by switching trade partners.

3. Why might a government subsidize the production of certain crops?

4. Why might a government impose a tariff on imports of certain agricultural products?

5. Describe at least one important difference between program food aid and project food aid:

6. List the three parties involved in a TFAT, and explain the role of each:

7. Which of the following decreased between 1980 and 2010 (circle all that apply)?
   a. Total emergency food aid deliveries
   b. Total food aid deliveries
   c. The share of total food aid delivered to Africa
   d. The total quantity of food aid procured through local purchases
   e. The share of direct transfers in total food aid deliveries
   f. The share of the United States' contributions in total food aid deliveries

8. Based on your knowledge of 21st-century food aid trends, select the most likely scenario from the options below:
   a. Corn grown in Iowa is shipped to the Horn of Africa for emergency distribution during a famine.
   b. A Canadian charity includes shipments of Canadian vegetable oil as a part of hunger relief efforts in Haiti.
   c. The Japanese government purchases wheat from Indian farmers for redistribution to extremely poor Indian households.

Current Events Case Study

In this exercise, you will apply your knowledge of food trade and food aid to a specific case study drawn from current global events. Search the Internet or your local paper for a recent news article that addresses some aspect of agricultural trade and/or food aid. **Your article must focus on a specific country or countries to appropriate for this exercise, i.e. do not choose an article that deals with the topic of global food aid or agricultural trade only in a general sense.** Your article may mention trade, food aid, or both; however, you should focus exclusively on either trade or on food aid (not both) as you complete the exercise.

Begin by reading your article carefully. Make sure that you understand the central message, relevant background, and key terms—consult a dictionary or perform an Internet search for explanations of unfamiliar terms and phrases. If your article mentions more than one country, **choose one country** to focus on in the exercise.

The questions below will guide you through the process of understanding, contextualizing, and analyzing your article. Answer each question thoroughly; be sure to back up your claims with logical explanations, drawing from your previous work in this lesson. You may find it helpful to read through all of the questions before you begin work.

Type or neatly write your answers on a separate sheet, and submit them with a copy of your article attached. You should also prepare to briefly summarize your article, statistics, and reflections for your classmates.

For extra credit, you may choose to present your results on a poster. Include the text of your analysis (answers to the questions below), and present your statistics in a table. Also include relevant photos or other images, and a map showing the location of your country and its trading partners; use arrows to indicate trade or food aid flows (e.g., an arrow showing the export of coffee from your country to a trading partner; another arrow showing the inflow of food aid, with the annual quantity labeled).

Article title:

Article date:

Article source:

Country focus (your country for the exercise):

List unfamiliar terms/phrases, with complete definitions/explanations:

Article summary: Summarize the key messages of the article in a few concise sentences. Be sure to note the specific country(s) and crops or other tradable products mentioned in the article.

Describe benefits of agricultural trade (or food aid) mentioned or alluded to in the article:

Describe drawbacks of agricultural trade (or food aid) mentioned or alluded to in the article:

Statistics:

Consult the suggested source, or another credible source, for the following statistics regarding your country's economy, trade profile, and food aid profile (note: include statistics on food aid even if your article focuses on trade, and vice versa).

- Available from the CIA World Factbook:
  - o GDP per capita (average income per person)
  - o Percent of workforce employed in agriculture
  - o Population below the poverty line
  - o Agricultural products
  - o Exports
  - o Imports
  - o Trade partners (exports and imports)
- Available from the World Food Programme (Quantity Reporting Database):
  - o Is the country a recipient of food aid? If so:
    - How much total food aid does the country receive?
    - How much emergency, project, and program food aid does the country receive?
    - How much food aid does the country receive through direct transfers, local purchases, and triangular purchases?
  - o Is the country a food aid donor? If so:
    - How much total food aid does the country donate?
    - How much emergency, project, and program food aid does the country donate?
    - How much food aid does the country donate through direct transfers, local purchases, and triangular purchases?

Describe at least one way that the statistics that you collected enhance your understanding of the article's message and claims.

Describe at least one potential inconsistency between the statistics that you collected and the information or conclusions mentioned in the article. What do you think might account for this inconsistency?

Based on both the article and your statistics, assess the overall impact of food trade (or food aid) on food security in your country:

- How does trade (aid) enhance food security?
- How might trade (aid) undermine food security? Consider both short and long-term effects.
- How might your country adjust its trade policies, or its approach to food aid, to better promote food security?

Based on both the article and your statistics, describe how your country's trade policies or participation in food aid might affect food security in other countries. Consider both positive and negative effects in both the short and long term. If possible, mention specific countries or regions that might be most heavily affected by your country's policies.

List at least two questions that you still have after reading, contextualizing, and analyzing your article. Your questions should be related to any aspect of your work in this exercise (e.g., you may have questions about the content of your article or about the details of your country's trade profile; you may want additional information to assess the food security impact of your country's policies; etc.).

Case Study Presentation Notes

Use this sheet to record notes on your group members' case study presentations. You may use the back of the sheet or attach an additional sheet if you need more space.

Presenter name:

Article title:

Article focuses on (circle one): Food Trade Food Aid

Article summary:

Presenter's assessment of trade/aid impact on food security:

I agree/disagree (circle one) with the presenter's assessment because (cite specific examples or statistics from the presentation):

Presenter name:

Article title:

Article focuses on (circle one): Food Trade Food Aid

Article summary:

Presenter's assessment of trade/aid impact on food security:

I agree/disagree (circle one) with the presenter's assessment because (cite specific examples or statistics from the presentation):

Presenter name:

Article title:

Article focuses on (circle one): Food Trade Food Aid

Article summary:

Presenter's assessment of trade/aid impact on food security:

I agree/disagree (circle one) with the presenter's assessment because (cite specific examples or statistics from the presentation):

Food Trade and Food Aid Crossword Puzzle

Directions: The crossword puzzle below contains key terms related to food trade and food aid. Use the clues and your knowledge from this lesson to complete the puzzle.

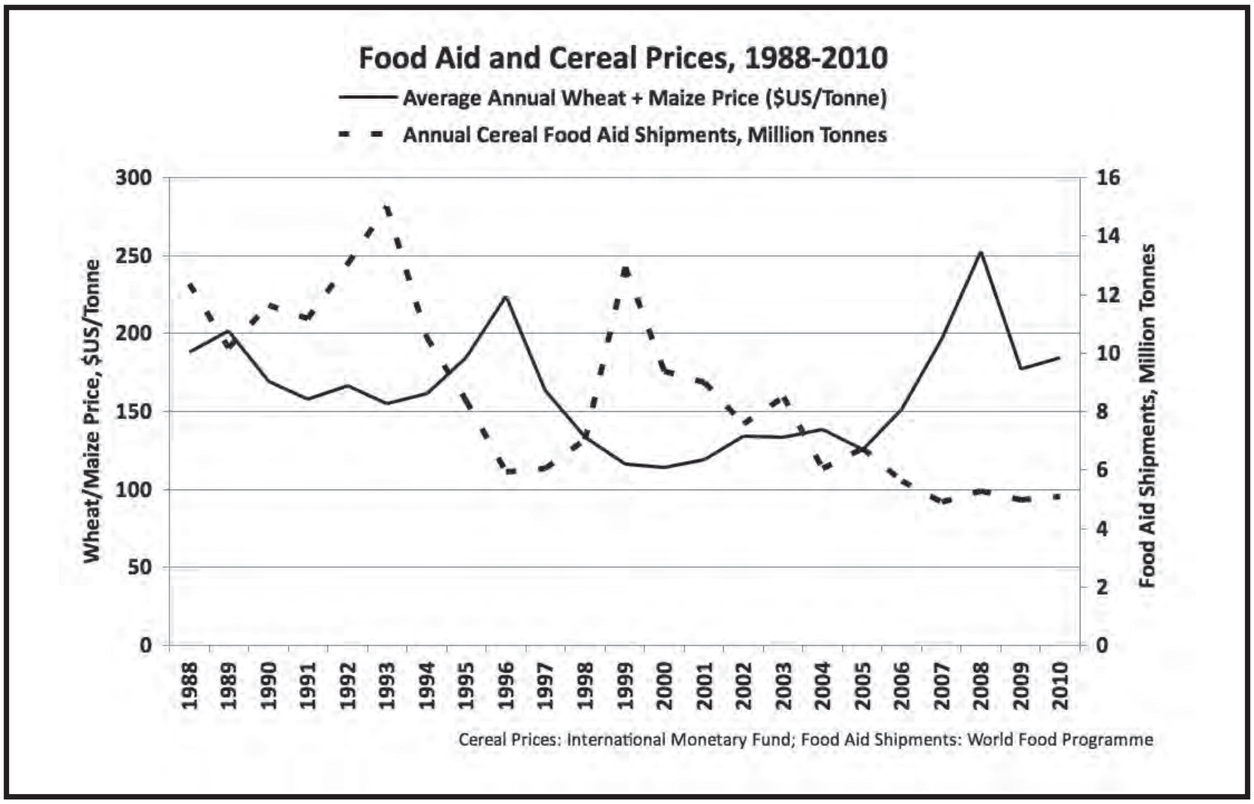
ACROSS

1. A mandated maximum or minimum amount (in the context of trade, usually referring to the amount of a particular good to be imported or exported)
4. Collective term for all economic activity related to a particular type of good or service
5. __________ Food Aid Transaction: a mode of food aid procurement in which the donor country purchases food from a third-party country for distribution in a recipient country
7. Food self-___________: the ability to either produce domestically, or purchase on world markets at market prices, sufficient food to feed the domestic population
9. ________ food aid: food aid distributed as a part of ongoing efforts to promote food security and economic development
13. Sale of donated food to generate funds for other development programs
14. A tax levied on traded goods
15. A cost or benefit of production or consumption that is not reflected in market prices
16. A direct or indirect payment intended to promote economic activities deemed to be beneficial to society

DOWN

2. ________ advantage: a situation in which one country can produce a good more efficiently than another
3. __________ Organization: an international agency that promotes free trade and helps countries negotiate fair rules and policies for trade
6. Continent receiving the majority of world food aid shipments
8. Domestically produced goods moved out of a country through sale or donation
10. Food self-___________: the ability to produce sufficient food domestically to feed the domestic population
11. _________ advantage: a situation in which a country produces two or more goods more efficiently than another country, but has a greater efficiency advantage in producing one of the goods. Also: an economic principle that explains how countries benefit from trade
12. Foreign goods moved into a country through purchase or donation

Food Aid and Cereal Prices



Questions for discussion:

1. What is the apparent relationship between the price of cereals and the quantity of food aid delivered?

2. Explain the food security consequences of this apparent relationship.

3. Propose an explanation for the apparent relationship.

Answer Key to Handout 1 (Introductory Quiz)

Answer each question to the best of your ability. The quiz is intended to help you begin thinking about the issues that will be addressed in this lesson—you are not expected to know every answer, and the quiz will not be graded. You will learn more about these topics over the next few days.

1. In 2010, the total volume of global trade in agricultural products was:
   a. Less than one-half of the volume in 1960
   b. About one-half of the volume in 1960
   c. About the same as the volume in 1960
   d. About twice the volume in 1960
   e. More than twice the volume in 1960

2. Which of the following regions imported more food than they exported in 2010? Circle all that apply:
   Africa **Asia** ***Europe*** North America South America
   **In Europe, imports and exports were roughly equal.*

3. True or false: Although its actions affect developing countries, the World Trade Organization has no representation from developing-country governments.
   True **False**

4. True or false: The term "food aid" refers only to no-cost donations of food intended to improve food security in the recipient country.
   True **False**

5. True or false: Food aid donations always consist of crops grown in the donor country.
   True **False**

6. Which region received the most food aid in 2010?
   Africa Asia Europe North America South America

7. True or false: Most food aid donations are in the form of wheat, maize, and other grains.
   True False

Answer Key to Handout 4 (Agricultural Trade Worksheet)

Instructions: Carefully review Handout 1, *Agricultural Trade—Benefits and Risks, and Regulations*, and use the information in the handout to answer the questions below. You may work alone or with a partner, but be sure to provide a thorough response to each question on your own worksheet. Your teacher will collect the worksheets for evaluation at the end of the lesson.

Briefly define the following terms:

- Food self-sufficiency

A country is food self-sufficient if domestic farmers produce enough food to meet domestic consumption demands.

- Food self-reliance

A country is food self-reliant if domestic firms, individuals, and the government can purchase enough food in commercial markets to meet domestic consumption demands (compensating for any shortfall in domestic food production, i.e., any deficit in food self-sufficiency).

- Quota

A mandated maximum or minimum amount; for example, and import quota usually specifies the maximum quantity of a particular good that a country will import.

- Tariff

A tax levied on traded goods.

- Subsidy

A direct or indirect payment, usually granted by a government, intended to promote economic activities deemed to be beneficial to society.

- Externality

An "external" cost or benefit of a product that is not reflected in the market (i.e., sale or purchase) price of the product.

During the 20th century, the value and importance of international trade in agricultural products ________________ (increased/decreased/remained constant).
Increased

In 2009, which of the following regions had an agricultural import-export ratio of greater than one (i.e., import value greater than export value)? Select all that apply.

a. *Africa*
b. *Asia*
c. Europe
d. North America
e. South America

Country A produces corn, and Country B produces soybeans. In an effort to increase domestic food production, Country A decides to offer tax breaks for farmers who plant an additional soy crop between rotations of corn. How might the tax break affect farmers in Country B? Explain your answer, including any assumptions you make.

The tax break is likely to have a negative impact on farmers in Country B. As soy production in Country A increases, imports from Country B will fall, reducing total income from soy farming in Country B. If Country A produces a surplus of soybeans for export, farmers in Country B will have to compete with exports from Country A for their share in the international market—and if the tax break significantly lowers production costs in Country A, Country A's farmers will be willing to accept a lower price for soybeans than Country B's farmers, making competition difficult for Country B.

Key assumptions:

- *Country A currently imports soybeans from Country B but would cease to do so if they could produce more soybeans domestically.*
- *The tax break is effective, i.e., reduces the cost and increases the quantity of production.*
- *Country B also exports soybeans to other countries, and those countries would be open to importing from Country A if Country A exported soybeans at a lower price.*

Scientists in Country M have just confirmed that the country's soil nutrient profile is uniquely suited to the production of citrus fruit. Country M currently imports citrus from Country C, but would now like to exploit its natural advantage to meet domestic demand and become an exporter in its own right. However, farmers in Country M have never grown citrus and will need time to build new infrastructure and adjust their practices.

1. What actions might the government of Country M take to support growth of the citrus industry? List as many options as you can think of.
   Student responses will vary, but should mention at least one of the following options:
   - *Offer subsidies and incentives (direct payments, tax breaks, free or reduced-cost inputs and infrastructure, etc.) for farmers who plant citrus crops; or*
   - *Restrict imports of citrus from Country C (using a tariff or an import quota) to ensure domestic producers a greater share of the domestic citrus market.*

2. Which, if any, of the actions described above would you advise the government to take? Explain, focusing on consequences in both the short and long term, internationally as well as domestically.
   Student responses will vary. Good answers may consider the following issues:
   - *Farmers may become reliant on or accustomed to generous subsidies, and it may be difficult to reduce subsidies even when the citrus industry is well established;*
   - *Import restrictions may lead to political tension or retaliation from Country C (e.g., Country C may restrict imports of certain products from Country M); or*
   - *If the cost of citrus rises as a result of import restrictions, domestic consumers may substitute away from citrus and toward other products (e.g., they may buy apples instead of oranges) rather than purchasing expensive domestic citrus.*

Describe a scenario in which frictional costs of trade might deter a country from exporting a product in which it has a strong comparative advantage in production.

Student responses will vary. Two sample responses are provided below:

- *The climate of Country X is exceptionally well suited to growing coffee beans; however, coffee is currently grown only on small farms in rural, roadless areas, and the cost of transporting the beans to seaports and airports exceeds any profit that might be generating by selling them on the international market.*
- *The Unifruit grows only in Country Y, and is considered a delicacy around the world. However, the fruit begins to spoil extremely rapidly after it is picked, and no reliable method of preservation during transport exists. Therefore, although the fruit would fetch an extremely high export price, it is sold only in local markets.*

Describe a scenario in which a social or environmental externality would undermine gains from trade.

Student responses will vary. Sample response: In Country Z, laws regulating fishing in freshwater lakes and rivers are unusually lenient. Using aggressive gear and methods that are illegal in other countries, local fishermen are able to catch many fish for very low cost. High demand for these fish in international markets motivates the fishermen to maximize their annual catch, and for a few years, exports of freshwater fish account for a significant share of the national income. However, aggressive fishing depletes fish populations, and human activity around lakes and rivers pollutes aquatic environments. Ultimately, the country suffers huge losses when the fishing industry collapses, and the government is forced to undertake a costly cleanup effort to ensure safety of the water supply.

In Country R, rice farming is the only economic activity, and rice is the major food staple. Rice production is labor-intensive, and yields are low. In Country Q, large industrial farms produce rice in large quantities at little cost. Country Q also produces a variety of other food products.

a. Which country has the comparative advantage in rice production? Explain.

Country R has the comparative advantage in rice production. Because rice is the only product that Country R produces, the country sacrifices nothing by devoting all of its resources to rice production.

b. If Country R begins importing rice from Country Q, will food security in Country R improve? Explain.

(Student answers may vary. Award credit for any logical argument that draws on the lesson material. One such argument is outlined below).

Commercial imports are unlikely to improve food security. Because rice farming is the only way to earn money in Country R, the citizens of Country R could not afford to purchase imports unless they earned a profit from sale of the domestic rice crop; however, the imports themselves are likely to make domestic rice farming less profitable, as they will compete with the domestic crop in local markets.

c. If Country Q donates rice to Country R through an international food aid program, will food security in Country R improve in the short run? In the long run? Explain.

(Student answers may vary. Award credit for any logical argument that draws on the lesson material. One such argument is outlined below).

Assuming that domestic rice farmers do not currently produce enough rice to satisfy domestic demand, food aid is likely to improve food security in the short term, as long as food aid does not displace commercial sales of the domestic rice crop. However, food aid should not be considered a long-term solution to Country R's food security problem; reliance on aid shipments may reduce the incentive for development of Country R's agricultural sector, and if Country Q withdraws aid for political or economic reasons, hunger in Country R will return to its previous level.

d. How do you think that Country Q could best help to improve food security in Country R?

Student answers may vary. Award credit for any logical suggestion that draws on the lesson and unit material. Example: Country Q could train rice farmers in Country R in more efficient techniques, and/or help farmers learn to grow other crops.

In Country X, farmers require 10 kilograms of fertilizer to produce 1 tonne of wheat and 5 kilograms of fertilizer to produce 1 tonne of maize. In Country Y, farmers require 3 kilograms of fertilizer to produce 1 tonne of wheat and 2 kilograms of fertilizer to produce 1 tonne of maize.

a. Which country has the comparative advantage in maize production?

Country X; Country X produces maize twice as efficiently as wheat, while Country Y produces maize only one and one-half times as efficiently as wheat.

b. Suppose each country has access to 90 kilograms of fertilizer. According to the principle of comparative advantage, how much of each crop should Country X and Country Y respectively produce?

Each should produce only the crop in which they have a comparative advantage: Country X should produce 90/5 = 18 tonnes of maize, and Country Y should produce 90/3 = 30 tonnes of wheat.

c. If the two countries produce the quantities you found in (b):

i. Suggest a trade that would make Country X better off, and Country Y no worse off.
Country X gives Country Y 3 tonnes of maize in return for 2 tonnes of wheat. Country X now has 15 tonnes of maize and 2 tonnes of wheat; had Country X produced 2 tonnes of wheat, using 20kg of fertilizer, they would have had enough fertilizer left to produce only 70/5 = 14 tonnes of maize. Country Y now has 28 tonnes of wheat and 3 tonnes of maize; had Country Y produced 2 tonnes of maize, using 6kg of fertilizer, they would have had enough fertilizer left to produce 84/3 = 28 tonnes of wheat. Thus, Country X is better off, and Country Y is no worse off.

ii. Suggest a trade that would make Country Y better off, and Country X no worse off.
Using the same logic as in (i), if Country X gives Country Y 2 tonnes of maize in return for 1 tonne of wheat, Country Y is better off and Country X is no worse off.

iii. Which trade do you think is more likely to take place? Why?
Based on the data provided, Country Y is more efficient in agricultural production. If this efficiency reflects a higher level of overall economic development, Country Y likely has the advantage over Country X in trade negotiations, and the second trade (making Country Y better off) is more likely to occur.

List two major goals of the World Trade Organization:

1. *Help countries negotiate trade rules and policies and resolve disputes*
2. *Remove barriers to free trade (tariffs, quotas, subsidies)*

Answer Key to Handout 6 (Food Aid Worksheet)

Graph Analysis Questions:

Classifying food aid by commodity

1. (Graph 1) Describe changes in the total annual quantity of food aid delivered between 1977-2006. In what years were deliveries the highest? The lowest?
   Overall, the total annual quantity of food aid delivered declined from 1977 to 2006. Deliveries reached their highest point in the early 1990s (1992) and as of 2006 were at a three-decade low.
2. (Graph 1) Describe changes in the total annual quantity of non-cereal food aid deliveries between 1977 and 2006. In what years were non-cereal deliveries the highest? The lowest? Describe any apparent relationship between total deliveries and non-cereal deliveries.
   Non-cereal deliveries appear to have increased slightly between 1977 and 2006. Non-cereal deliveries were highest around 1992–1993 and in 1999—years in which total food aid deliveries also peaked, suggesting a possible positive correlation between non-cereal deliveries and total deliveries. However, non-cereal deliveries appear to have been lowest in the 1970s and early 1980s, when total deliveries were high relative to the 21st century.

Classifying food aid by donor

3. (Graph 2)
   a. Describe how the total annual quantity of cereal food aid donated by the United States changed between 1977 and 2006.

   United States donations of cereal food aid held steady at around 6–7 million tonnes annual during the 1980s and reached a peak of about 8 million tonnes around 1992 before declining significantly in the mid-1990s. After a resurgence around 1999, donations began a steady decline in the early 21st century, reaching a low of about 2 million tonnes in 2006.

   b. Describe how the United States' share of total cereal food aid donations changed between 1977 and 2006.

   (Note: Shares may be more difficult to estimate from the graph, so student responses may vary slightly). The United States' share of total cereal food aid donations declined between 1977 and 2006, falling from about two-thirds to about half of total donations. The U.S. share appears to have been higher, in general, in years of high total donations.

Classifying food aid by recipient (region)

4. (Graph 3) For the period 1977–2006 (shown on the graph), fill in the blanks and explain each of the following trends:
   a. The ___________________ (increase/decrease) in food aid shipments to Asia

   Explain:

   Decrease; crop production increased rapidly in Asia following the Green Revolution of the 1960s and 1970s, reducing the need for food aid and imports.

b. The ____________ (increase/decrease), followed by ____________ (increase/decrease) in food aid shipments to Africa

Explain:

Increase, followed by decrease; explanations may vary. Sample explanation: international attention and resources turned to Africa in the 1980s as food security in Asia improved; as development efforts in Africa took effect, the need for food aid gradually declined.

c. (Bonus) Explain the spike in food aid shipments to Eastern Europe in the early 1990s:

Student responses may vary. The best explanation is probably the end of the Cold War and the fall of the Berlin War in 1989, which opened Eastern Europe to development aid from the United States and other Western nations.

Classifying food aid by mode of delivery

5. (Graph 4) Describe how the balance of program, project, and emergency food aid changed between 1988 and 2010. Which delivery mode(s) became more common during this period? Which became less common?

   Program food aid, which accounted for at least half of total food aid in the late 1980s and early 1990s, declined sharply to become the least common delivery mode in the early 21st century. Project food aid also declined slightly, although its share increased due to the decline of program food aid. Emergency food aid increased in both total quantity and relative share, reaching new highs in the first decade of the 21st century.

6. (Graphs 6 and 7) Of the major donors shown in Graph 7 (2010), which country most heavily favored each of the following food aid delivery modes (i.e., delivered the largest share of its food aid donations via the indicated delivery mode)?

   a. Program: Japan

   b. Project: the United States

   c. Emergency: Australia

   If these rankings changed between 1990 and 2010, describe the change.

   Yes, the rankings changed significantly. In 1990, Canada and Australia gave the most program food aid, Japan gave the most project food aid, and the European Community gave the most emergency food aid. In general, large donors have shifted away from program food aid and toward emergency food aid, reflecting the overall trends shown in Graph 4.

Classifying food aid by mode of procurement

7. (Graph 5) Describe how the balance of direct food aid transfers, local food aid purchases, and triangular food aid purchases changed between 1988 and 2010. Which mode(s) of procurement has/have become more common? Which has/have become less common?

   Direct transfers, which accounted for nearly 100% of deliveries in the late 1980s and early 1990s, declined sharply and comprised less than half of total deliveries in 2010. Both local purchases and triangular purchases increased slightly in quantity, and substantially in share. In 2010, triangular purchases accounted for the majority of food aid deliveries.

8. (Graphs 8 and 9) Of the major donors shown in Graph 9 (2010), which country most heavily favored each of the following food aid procurement modes (i.e. delivered the largest share of its food aid donations via the indicated procurement mode)?

a. Direct transfers: Japan
b. Local purchases: Australia
c. Triangular purchases: Canada

If these rankings changed between 1990 and 2010, describe the change.

Yes, the rankings changed significantly. In 1990, direct transfers accounted for nearly 100% of United States food aid shipments, while Japan favored local and triangular purchases.

Questions for Reflection and Discussion:

1. Do you think that cereal and non-cereal deliveries have different effects on food security? Why (or why not)?

   Student responses will vary; instructors may wish to suggest that students consider whether cereal and non-cereal deliveries have different nutritional impacts (especially on vulnerable populations such as young children, new mothers, and the elderly).

2. What factors might contribute to year-to-year variation in the total quantity of food aid delivered? Explain.

   Student responses will vary. To guide reflection and discussion, instructors may suggest any of the following possible factors:

   (Total quantity of deliveries)

   - *year-to-year variation in crop production in donating countries*
   - *year-to-year variation in crop production in recipient countries*
   - *economic conditions in donating and recipient countries*
   - *occurrence of food emergencies (e.g., events such crop failure, natural disasters, civil conflict, etc, which may seriously threaten food security)*

3. From a food security perspective, do you think that it is it better to have food aid donations coming mostly from one country, or to have many countries making smaller donations? Explain your answer.

   Student responses will vary. Key ideas may include:

   - *It is better to have donations come from many different countries because countries can provide a greater total quantity, as well as a greater variety, of food aid by pooling resources.*
   - *It is better to have donations come from many different countries because donating countries also benefit from food aid (e.g., by selling surplus crops at concessional prices, gaining international market exposure, or gaining status in the international community).*
   - *It is better to have donations coming primarily from one country (or passing through a single country or agency) because coordination problems among many donating countries may compromise the efficiency of food aid delivery.*

4. What factors do you think may have contributed to the changes in the balance of program, project, and emergency food aid that you noted in question 1? Explain.

   Student responses will vary. Students may note that a decline in the total quantity of food aid deliveries—perhaps accompanied by a higher frequency and severity of food crises in the 21st century—would result in increased use of emergency and targeted program food aid delivery modes, and a decreased use of less-direct program delivery channels.

5. Of the three main food aid distribution modes—program, project, and emergency—which do you think is the least likely to improve food security? Which do you think is most likely to improve food security? Thoroughly explain your response.

   Student responses will vary. Key ideas may include:

   - *Program food aid is least likely to improve food security because it is usually sold rather than donated, and thus may not reach the poorest countries or households*
   - *Emergency food aid is least likely to improve food security because it is reactive and not proactive (i.e., emergency donations may be a short-term solution, but needy households will slip back into chronic hunger after the acute crisis passes and the aid is withdrawn)*
   - *Emergency food aid is most likely to improve food security because it directly targets the neediest households in times of acute crisis*
   - *Project food aid is most likely to improve food security because it accompanies general development efforts that will gradually enhance needy households' capacity to provide for themselves.*

6. What factors do you think may have contributed to the changes in the balance of direct food aid transfers, local food aid purchases, and triangular food aid purchases that you noted in question 1? Explain.

   Student responses will vary. Students may note that an increase in local and triangular purchases reflects an increase in food production capacity in lower and middle-income countries, and an increasing desire on the part of the international community to support farmers in these countries. Direct transfers may also have declined as a result of increased consumption of domestic commodity crops (particularly maize) for biofuel production in higher-income countries.

7. Of the three main food aid procurement modes—direct transfers, local purchases, and triangular purchases—which do you think is the least likely to improve food security? Which do you think is most likely to improve food security? Thoroughly explain your response.

   Student responses will vary. Key ideas may include:

   - *Direct transfers are least likely to improve food security because the influx of cheap foreign food hurts poor farmers and undermines the development of a productive domestic agricultural industry, which is essential for long-term food security*
   - *Local purchases are least likely to improve food security because poor countries will not be able to produce food as efficiently or abundantly as richer countries; thus, relying on local purchases reduces the total quantity of food aid available*
   - *Local purchases are most likely to improve food security because they support domestic farmers*
   - *Direct transfers are most likely to improve food security because they rely on efficient, abundant food production in developed countries*
   - *Triangular purchases are most likely to improve food security because they support the development of agriculture in middle-income countries while simultaneously providing relief for the poorest countries; thus, triangular purchases affect the largest possible number of potentially food-insecure households.*

Answer Key to Handout 7 (Quiz—Food Trade and Food Aid)

1. For each of the following regions, describe important changes in the volume of agricultural trade (imports, exports, total) during the period 1960–2009:

   a. World

   Total quantity of trade increased dramatically (more than 10 times)

   b. Europe

   Imports decreased relative to exports

   c. South America

   No significant change in import-export ratio (increased slightly); presumably, total quantity increased in keeping with global trend

   d. Africa

   Import-export ratio increased significantly

   e. Asia

   Import-export ratio increased significantly

2. Which of the following illustrates the principle of comparative advantage?

   a. By hiring a staff of skilled diplomats, the wealthy government of Country A is able to negotiate a favorable trade deal with Country B

   b. In the midst of a prolonged drought, Country A chooses not to install expensive irrigation equipment; instead, farmers switch to growing drought-tolerant crops, which they trade for tropical plants grown in Country B

   c. Country B learns that Country C is exporting corn for a lower price than Country A and reduces import costs by switching trade partners.

   Answer: B

3. Why might a government subsidize the production of certain crops?

   Student responses will vary. Award credit for responses that demonstrate understanding of the purpose of a subsidy, e.g., a government might subsidize corn production to increase domestic corn supplies or to reduce poverty among corn farmers.

4. Why might a government impose a tariff on imports of certain agricultural products?

   Student responses will vary. Award credit for responses that demonstrate understanding of the purpose of a tariff, e.g., a government might impose an import tariff on corn to protect domestic corn farmers from competition with more efficient farmers in more highly developed countries.

5. Describe at least one important difference between program food aid and project food aid.

   Student responses may vary; most responses, however, should note that program food aid may be sold at a concessional price to the recipient government rather than donated, and that its primary purpose may be to generate revenue rather than to improve food security.

6. List the three parties involved in a TFAT, and explain the role of each:
   - *Recipient country: receives food aid (the recipient is usually a low-income country)*
   - *Donor country: purchases food from a third (producing) country to donate to recipient country (the donor is usually a high-income country)*
   - *Third country/producing country: produces food purchased by donor country (the third country is often a middle-income country)*

7. Which of the following decreased between 1980 and 2010 (circle all that apply)?
   a. Total emergency food aid deliveries
   b. Total food aid deliveries
   c. The share of total food aid delivered to Africa
   d. The total quantity of food aid procured through local purchases
   e. The share of direct transfers in total food aid deliveries
   f. The share of the United States' contributions in total food aid deliveries

   Answer: B, E, and F

8. Based on your knowledge of 21st-century food aid trends, select the most likely scenario from the options below:
   a. Corn grown in Iowa is shipped to the Horn of Africa for emergency distribution during a famine
   b. A Canadian charity includes shipments of Canadian vegetable oil as a part of hunger relief efforts in Haiti
   c. The Japanese government purchases wheat from Indian farmers for redistribution to extremely poor Indian households.

   Answer: A

Answer Key to Handout 10 (Food Trade and Food Aid Crossword Puzzle)

ACROSS

1. A mandated maximum or minimum amount (in the context of trade, usually referring to the amount of a particular good to be imported or exported)
4. Collective term for all economic activity related to a particular type of good or service
5. _________ Food Aid Transaction: a mode of food aid procurement in which the donor country purchases food from a third-party country for distribution in a recipient country
7. Food self-___________: the ability to either produce domestically, or purchase on world markets at market prices, sufficient food to feed the domestic population
9. _______ food aid: food aid distributed as a part of ongoing efforts to promote food security and economic development
13. Sale of donated food to generate funds for other development programs
14. A tax levied on traded goods
15. A cost or benefit of production or consumption that is not reflected in market prices
16. A direct or indirect payment intended to promote economic activities deemed to be beneficial to society

DOWN

2. _______ advantage: a situation in which one country can produce a good more efficiently than another
3. __________ Organization: an international agency that promotes free trade and helps countries negotiate fair rules and policies for trade
6. Continent receiving the majority of world food aid shipments
8. Domestically produced goods moved out of a country through sale or donation
10. Food self-___________: the ability to produce sufficient food domestically to feed the domestic population
11. ________ advantage: a situation in which a country produces two or more goods more efficiently than another country, but has a greater efficiency advantage in producing one of the goods. Also: an economic principle that explains how countries benefit from trade
12. Foreign goods moved into a country through purchase or donation

Answer Key to Projection (Food Aid and Cereal Prices)

Questions for discussion:

1. What is the apparent relationship between the price of cereals and the quantity of food aid delivered?
   Food aid shipments are lower in years of high cereal prices and vice versa. This relationship is sometimes referred to as "countercyclical," i.e., food aid and food prices follow opposite cycles.

2. Explain the food security consequences of this apparent relationship.
   Student explanations may vary, and the subtleties of producer-consumer dynamics in a particular region or year (i.e., the effects of high vs. low prices on small farmers, the effects of foreign food aid shipments on domestic farm incomes, etc.) will determine the actual food security outcome. The simplest response, however, would be to say that the relationship almost always has negative consequences. Poor households generally have a harder time obtaining food in times of high prices, so any decline in food aid shipments in a high price year will exacerbate food insecurity.

3. Propose an explanation for the apparent relationship.
   Several explanations are possible. Two logical explanations are offered below, one focusing on price as a driving factor, and the other focusing on supply and demand:
   - *When prices are high, farmers want to sell as much of their output as possible at the high price, and are less likely to donate or sell at a discounted price to government food aid programs, since to do so would mean a greater loss of profit than in a low-price year. Governments and charities cannot afford to purchase as much food at the higher prices, so food aid shipments will fall.*
   - *According to economic principles, high prices generally reflect low supply, while low prices reflect high supply. We can infer that in high-price years, cereals are in short supply, and there is little surplus to be donated as food aid after all commercial transactions have taken place. In low-price years, supply must be abundant, and food aid is a convenient way to put surplus crops to use.*

Lesson Six

Emerging Food Security Challenges

Part One: Biofuels

Organizing Questions

- What are biofuels?
- Why did interest in biofuels increase around the beginning of the 21st century?
- What are the advantages and disadvantages of using different types of biofuels to replace conventional fuels (such as gasoline)?

Introduction

This lesson introduces one emerging challenge to global food security: the use of food crops in the production of biofuels. The lesson opens with an introductory reading that defines a biofuel, summarizes reasons for rising interest in biofuels, and presents advantages and disadvantages of replacing fossil fuels with biofuels. Students learn about trends in biofuel production and consumption, and consider the pros and cons of biofuel development. By quantifying the social and environmental effects of converting corn to ethanol, and by conducting detailed research on a range of biofuel feedstocks, students prepare to respond to an important question in modern food and energy security debates: Should we be converting food crops to fuel?

Objectives

In this lesson, students will

- define “biofuel” and contrast biofuels with fossil fuels;
- recognize how global trends have contributed to an increased interest in biofuels;
- appreciate the advantages and disadvantages of replacing fossil fuels with biofuels;
- quantify the effects of biofuel development on food security and carbon emissions;
- explore the properties of different biofuel feedstocks; and
- make and defend concrete recommendations regarding biofuel and feedstock development.

Materials

- Handout 1, *Introduction to Biofuels*
- Handout 2, *Group Project Instructions*
- Handout 3, *Activity: One Tonne of Corn*
- (Optional) Handout 4, *Lecture summary: “Biofuels: The changing nature of agricultural demand”*

- (Optional) Handout 5, *Reading guide: Lecture Summary, "Biofuels: The changing nature of agricultural demand"*
- Teacher Information, *Biofuel Feedstocks Fact Sheet*
- Answer Key, *Introduction to Biofuels*
- Answer Key, *Activity: One Tonne of Corn*

Equipment

- Poster boards for the group project (one per group, based on four or five students per group)
- Internet and printer-ready computers for student research use

Teacher Preparation

1. Review all handouts, and make the correct number of copies (one per student, unless otherwise indicated).
2. Arrange the room for group work throughout the lesson. If desired, form project groups and assign feedstocks prior to Day One.
3. Review the Teacher Information, *Biofuel Feedstocks Fact Sheet*. This sheet contains basic information and research sources that should help instructors guide and evaluate student work during the group project.
4. Review Handout 4, and determine whether the optional reading is appropriate for the class. If so, make the appropriate number of copies.

Time

The complete lesson requires at least three 50-minute class periods. Students also complete a homework assignment prior to Day One. Options for extending or shortening the lesson are provided in the Extensions and Excerpts section, below.

Procedures Before Day One

Inform students that they will be learning about biofuels and their effects on food security. Distribute one copy of Handout 1 to each student. Ask students to complete the reading and activity before the next class period.

Day One

1. (5 minutes) Ask students to take out Handout 1 and to spend a few minutes reviewing the graph analysis questions with a neighbor. The instructor may circulate among students during this time to resolve any questions; use the Answer Key as a guide.
2. (10 minutes) Lead the class in a discussion of the questions that appear at the end of Handout 1. Refer to the Handout 1 answer key to guide the discussion and refine students' ideas.
3. (25 minutes) Divide the class into groups of four or five students for the group project (the instructor may wish to form these groups in advance). Distribute one copy of the project instructions to each group. Assign each group to a feedstock (see Notes on Assigning Feedstocks, below). Instruct students to read the instructions carefully and to begin work on the project: researching their feedstock, dividing

tasks, etc. If desired, distribute or suggest research sources to some or all groups at this time.

4. (10 minutes) With about 10 minutes remaining in the period, bring the class back together and distribute one copy of Handout 3 to each student. Explain the activity and answer any questions. Instruct students to complete the quantitative portion of the activity for homework (students should review the discussion questions but do not need to write formal answers) in addition to continuing work on the group project.
5. Collect Handout 1 for evaluation.

Day Two

1. (10 minutes) Ask students to reassemble in their project groups, and to take out Handout 3. Give students about 10 minutes to discuss the quantitative questions with their group (groups that finish early should begin to address the discussion questions).
2. (10 minutes) Lead the class in a brief discussion of the questions on Handout 3. Student responses to the questions will vary; encourage students to make specific references to their calculations, to the material in the introduction, and to relevant findings from their group project research.
3. (30 minutes) Inform students that they will have the remainder of the period to continue work on the group project. Remind students that their final products will be a poster and a brief (three to four minute) oral presentation to their classmates. Distribute one poster board to each group; encourage students to spend some time before the end of the period planning their presentation and their poster layout.
4. At the end of the class period, inform students that they should finalize their projects for homework. Group presentations will occur during the next class period, and they will have only a few minutes at the beginning of that period to put finishing touches on their poster and to discuss the presentation as a group.
5. Collect Handout 3 for evaluation.

Day Three

1. (10 minutes) Ask students to assemble in their project groups. Inform the groups that they will have about 10 minutes to finalize their posters and rehearse their presentations.
2. (40 minutes) Bring the class back together, and call the groups forward one at a time to present their findings and recommendations. Allow about three minutes for each group’s formal presentation, and about 2 additional minutes for the group to answer questions from classmates.
3. At the end of the period, allow students to hang their posters in the classroom (or simply collect posters for evaluation).

Extensions and Excerpts

Extensions: The materials for this lesson include one optional reading, Handout 4, a news summary of a university lecture on the topic of biofuels and food security. Instructors should review the reading to determine its appropriateness for the class, given students' level and time constraints. The reading may be assigned as homework at any point after Day One. A reading guide (Handout 5) is also included to help students focus on key ideas in the summary.

Excerpts: Instructors with less time to devote may shorten this lesson by:

- omitting the group project: Use class time in Day One to complete the *One Tonne of Corn* activity, assign the optional reading as homework due on Day Two, and conclude the lesson with a discussion of the activity and reading on Day Two; or
- omitting the group presentations: Follow the procedures as indicated, but omit the presentation component of the group project. Collect the completed posters at the beginning of Day Three.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess the graph analysis exercises in Handout 1, *Introduction to Biofuels*, based on accuracy, using the Answer Key as a guide;
- Assess the quantitative activity in Handout 3, *One Tonne of Corn*, based on accuracy, using the Answer Key as a guide;
- Assess the group project based on overall research, analysis, and presentation effort, including the following specific criteria:
  - o Research:
    - Do the group's poster and presentation address a majority of the research questions listed in the project instructions? (At a minimum, students should address all the "Basic information" questions, at least one question from the "Feasibility" section, and at least one question from each sub-section of the "Impacts" section.)
    - Does the poster include at least two relevant images?
    - Does the language used in the poster and presentation demonstrate an accurate understanding of appropriate vocabulary?
    - Does the poster include a citations section with references to credible sources, including all sources supplied or suggestion by the instructor?
  - o Analysis:
    - Does the group (in both the poster and presentation) adopt and defend a clear position on use of this feedstock for biofuel production?
    - Does the group list supporting policies and/or caveats that indicate careful analysis of the recommendation's impact?

        - Does the group provide thoughtful, substantive responses to questions from peers following the presentation?
    - o Presentation:
        - Is the poster neat and well organized?
        - Is the presentation well organized and within the suggested time limit?
        - Do all group members have a chance to speak during the presentation?
- (Optional) Assess Handout 5, *Reading Guide: Lecture Summary, "Biofuels: The changing nature of agricultural demand,"* based on accuracy and effort. Use the Answer Key as a guide.
- Assess students' contributions to group work and class discussion based on
    - o accuracy and appropriateness of contributions;
    - o clear and succinct statement of comments, questions, and answers;
    - o attention to other student's questions and ideas;
    - o ability to follow and promote lively, productive discussion;
    - o open-mindedness and respect for other student's backgrounds and opinions;
    - o willingness and ability to compromise and incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
    - o willingness and ability to express confusion and request clarification from other students and the instructor.

Introduction to Biofuels

biofuel—a fuel produced from biological raw materials

A biofuel is a fuel produced from biological raw materials. Human civilizations have used some biofuels for centuries. Wood, grass, and animal dung, for example, are all biofuels. These materials are still used for home cooking and heating in many countries today.

fossil fuels—fuels that form deep in the earth through geologic processes acting on plant and animal remains.

In the early 21st century, many countries developed increased interest in using biofuels as substitutes for fossil fuels, particularly gasoline. Fossil fuels are fuels that form deep in the earth, through geologic processes acting on plant and animal remains.

Many factors have motivated the desire to substitute away from fossil fuels. Because the geologic processes that form fossil fuels are very slow, the supply of these fuels is limited in the short term, and human consumption is rapidly depleting that supply. As demand for gasoline increases (due to global population and income growth) and supply becomes less predictable, gas prices have risen to unprecedented levels, making any substitute product more attractive. Finally, burning of fossil fuels in car engines and power plants releases carbon dioxide and other gases that degrade air quality and contribute to global climate change.

biofuel feedstock—the biological raw material used to produce a biofuel; for example, corn is a common ethanol feedstock

Most biofuel feedstocks, on the other hand, are grown and harvested in a year or less, so supply is relatively stable and can even increase over time. Biofuels also tend to be cleaner burning than fossil fuels. Additionally, because they can be produced from a range of both wild and cultivated raw materials, biofuels may be a more reliably accessible fuel source for countries that lack large fossil fuel reserves. And using agricultural products to produce fuel opens a lucrative new market for the farmers who grow those products—including, potentially, very poor farmers in the developing world.

biodiesel—a substitute for diesel fuel produced from biological raw materials

first-generation biofuels—biofuels produced from food crops

second-generation biofuels—biofuels produced from inedible agricultural products such as shrubs, grasses, and fast-growing trees

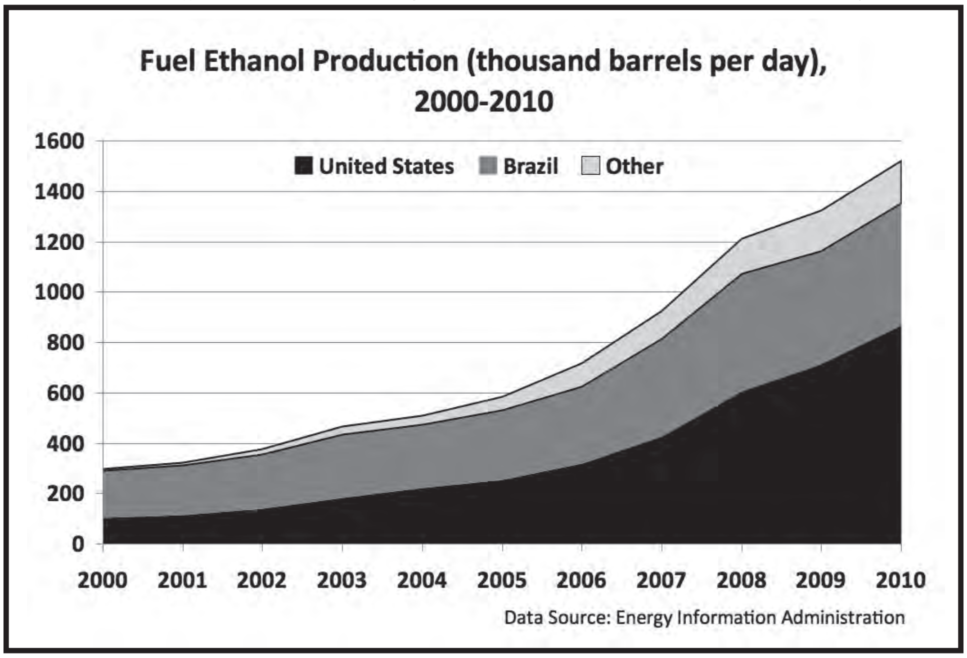
third-generation biofuels—biofuels produced from certain species of algae

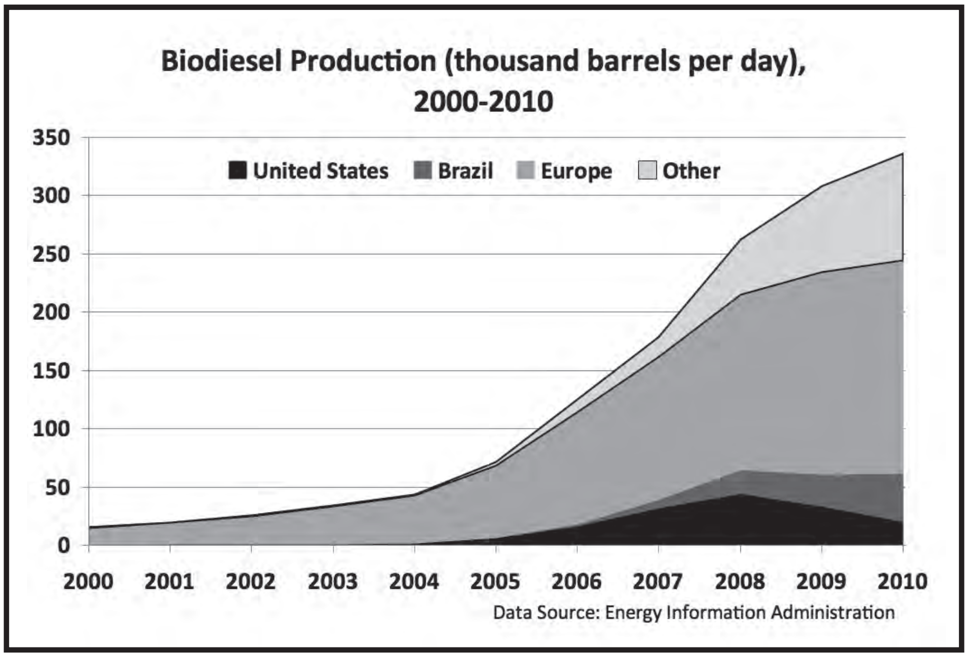
However, biofuel production also creates new problems. The most common biofuels on the market today are produced from food crops; ethanol, a gasoline substitute, is most often produced from sugar or corn, while diesel substitutes (biodiesels) are produced from oil crops such as soybeans. Demand for these crops from biofuel producers has reduced the quantity available for food consumption and thus contributed to sharp increases in food commodity prices. Expanding crop production to meet demand for both food and fuel will have other consequences—deforestation, water stress (due to increased withdrawals for irrigation), and pollution from fertilizers and pesticides.

Scientists are working to find a way around this food-fuel dilemma. Their efforts focus on advancing production technology from first-generation biofuels—biofuels produced from food crops—to second-generation biofuels produced from inedible agricultural products such as shrubs, grasses, and fast-growing trees. Ultimately, scientists hope to develop the technology to produce third-generation biofuels from certain species of algae.

Although early research and demonstration projects have shown some promise, many of the technical obstacles to commercial-scale production of second and third generation biofuels remain to be overcome.

Production of first-generation biofuels, however, has grown rapidly in response to demand. The two charts below show the growth in ethanol and biodiesel production during the first decade of the 21st century





In addition to recent production growth, these charts provide other useful information about global biofuels markets. Use this information to answer the following questions (you may need a calculator):

1. By how much did global biofuel production (ethanol and biodiesel combined) increase between 2000 and 2010? Express your answer as a percentage.
2. In 2010, what fraction of the total volume of biofuel produced was biodiesel? Ethanol?
3. Which country was the largest single producer of ethanol in 2000? In 2010?
4. Which country or countries produced the majority of the world's biodiesel in 2010?
5. Which of the following experienced the largest net growth between 2005 and 2010?
   a. Biodiesel production in Europe
   b. Biodiesel production outside Europe, the U.S., and Brazil
   c. Ethanol production in the United States
   d. Ethanol production in Brazil

For discussion:

- How would you characterize the major biofuel-producing countries with respect to economic and agricultural development?
- What biofuel feedstocks do you think might be used in these countries?
- Which countries might be included in the "other" bar on each graph? Do you think that these countries use the same feedstocks as the major producers? Explain your answer.

Group Project Instructions

Biofuels can be produced from a wide range of raw materials. Each has its own advantages and disadvantages as a biofuel feedstock—a crop that converts easily and efficiently into biofuel, for example, may be costly to grow; a crop that is already grow in large quantities at low cost may also be an important human food source.

In this activity, you will work in a small group to research a particular biofuel feedstock. Your teacher will assign you to one of the following feedstocks: **corn (maize), sugarcane, soybean oil, rapeseed oil, palm oil, jatropha, cellulosic feedstocks, or algae.** (Note: Smaller classes may cover only a few of these feedstocks, while larger classes may have more than one group assigned to each feedstock.) Your group is responsible for evaluating the pros and cons of this feedstock, and making a recommendation as to whether it should be used to produce biofuels. You will present your results on a poster and in a short oral presentation.

Use the following questions to guide your research. You may also wish to use the question categories (basic information, feasibility, etc.) to structure your poster—divide the poster into sections, with a heading and several bullet points or short sentences (and perhaps an image) for each category. You are not expected to address every question, but you should respond to as many as possible—be sure to address at least a few questions in each category. Leave space on your poster to cite your sources!

Your poster should include at least two images. Consider including any of the following:

- An image of the feedstock/feedstock plant
- Map of growing regions
- Images of production facilities
- Schemata of the biofuel production process
- Charts or tables showing the different uses of the feedstock, changes in feedstock price or supply, energy used at different stages of biofuel production, etc.

Your oral presentation should be three to four minutes in length. Include the following elements:

- A brief overview of the feedstock and biofuel production process (“Basic information” and “Feasibility”)
- A description of the impacts of using the feedstock to produce biofuel (“Impacts”—this should be the majority of the presentation)
- A summary of your group’s recommendation regarding use of this feedstock to produce biofuels

You may use your poster as a visual aid during your presentation. Try to ensure that each member of your group has a chance to speak.

Suggested resources:

Your teacher may suggest or provide some resources specific to your feedstock. The following general resources may be useful for all groups:

- The U.N. Food and Agriculture Organization, *State of Food and Agriculture 2008: Biofuels: Prospects, risks, and opportunities*. Available online from: http://www.fao.org/publications/sofa/en/ (scroll down to "previous editions")
- The United States Department of Agriculture Economic Research Service "Crop Briefing Rooms": http://www.ers.usda.gov/Browse/view.aspx?subject=Crops
- The Renewable Fuels Association: www.ethanolrfa.org
- News articles: Perform an Internet news search for "[your feedstock] +biofuel." Look for recent articles from credible sources that describe your feedstock's biofuel production potential, food security importance, and environmental effects.

Research questions:

- Basic information:
  - o Is this a first-, second-, or third-generation feedstock?
  - o Is this feedstock used to produce ethanol or biodiesel?
  - o Does this feedstock have other uses (e.g., as a food commodity)?
  - o Where (in what countries or regions) is this feedstock grown or produced?
  - o Which countries or regions currently use this feedstock in biofuel production?
- Feasibility:
  - o How advanced is the technology for producing the feedstock and converting it to biofuel?
  - o Does this feedstock currently account for a large share of global ethanol or biodiesel production?
  - o Does biofuel production from this feedstock create any useful by-products?
- Effects of using the feedstock to produce biofuels:
  - o How could use of this feedstock affect food availability and food prices? Consider (provide quantitative statistics where possible):
    - Has the quantity (i.e., percentage of total supply) of this feedstock used to produce biofuels increased in recent years? If so, by how much?
    - Does this feedstock account for a significant share of food calories, protein, or fat consumption globally or in certain developing regions?
    - Have prices for this feedstock in global food markets risen significantly in recent years? If so, by how much?
  - o How could use of this feedstock affect rural incomes in developing countries? Consider:
    - Is this feedstock uniquely suited to production in developing countries (e.g., grows well in a certain climate or on marginal land with minimal inputs)?
    - Do small farmers in developing countries currently grow this feedstock?
    - Is production in the developing world sufficient to supply a biofuel market, either domestically or internationally?

- o What are the environmental costs and benefits of using this feedstock?
  Consider:
  - Does large-scale feedstock production require extensive land area, intensive irrigation, or application of fertilizers and pesticides?
  - How much fossil fuel energy is required to convert the feedstock to biofuel?
  - What is the overall **fossil energy balance** of biofuel produced from this feedstock?

Fossil energy balance: the ratio of the energy contained in the biofuel relative to the fossil energy used in its production; e.g., an energy balance of 1.0 means that it requires as much energy to produce the biofuel as the biofuel contains.

- Recommendation:
  - o Would you support using this feedstock to produce biofuels (if production is not yet at the commercial scale, would you support investments in research and technology to support commercial-scale production)? Why or why not?
  - o If you do support using the feedstock to produce biofuels, what policies or regulations would you impost to mitigate negative effects?
  - o If you do not support using the feedstock to produce biofuels, under what circumstances would you change your recommendation?

Activity, One Tonne of Corn

In this activity, you will consider the effects of using corn as a fuel source. Replacing gasoline with corn-based ethanol reduces greenhouse gas emissions, but it also restricts the quantity of corn available for human consumption. But how much does the conversion of corn to fuel really affect the environment and the food supply? The questions below will help you quantify the pros and cons. After answering the questions, you will discuss the tradeoffs with your classmates.

For simplicity, we will assume that one gallon of 100 percent corn-based ethanol replaces an energy-equivalent volume of 100 percent gasoline. In reality, ethanol and gasoline are usually combined in varying ratios to create fuel blends, sometimes called *gasohol*. The gas you buy today probably has at least some ethanol in it already. Ethanol has been blended into gasoline at rates of up to 10 percent since 2005; the resulting fuel burns cleaner than pure gasoline, reducing air pollution.

We will also assume that producing and burning one gallon of corn ethanol reduces greenhouse gas emissions by about 15 percent compared with producing and burning one gallon of gasoline. This estimate, which is based on the U.S. Environmental Protection Agency's Life Cycle Analysis of Greenhouse Gas Emissions from Renewable Fuels,[9] takes into account the fossil fuel energy used in corn farming and ethanol production. The exact reduction in emissions varies, depending on farm practices and the efficiency of the technology used by the ethanol plant.

You may need a calculator. You'll also need to use the following conversions throughout the exercise:

One tonne (metric ton) = 1,000 kg

One tonne of corn = 39.4 bushels

How many tonnes of carbon dioxide emissions are avoided by converting one tonne of corn to ethanol?

Use the following information (and the assumptions and conversions above):

- One bushel of corn = 2.7 gallons of ethanol.[10]
- Ethanol is about 70 percent as efficient as gasoline (i.e., 10 gallons of ethanol can replace one gallon of gasoline).[11]
- Burning one gallon of gasoline releases about 8.9 kilograms of carbon dioxide into the atmosphere.[12]

9 http://www.epa.gov/otaq/renewablefuels/420f09024.htm
10 USDA, "Ethanol Reshapes the Corn Market," *Amber Waves*, April 2006
11 Energy Information Administration
12 U.S. EPA Greenhouse Gas Equivalencies Calculator, http://www.epa.gov/cleanenergy/energy-resources/calculator.html, accessed 19 April 2012

How many people can one tonne of corn feed?

Use the following information:

- Minimum Dietary Energy Requirement for sub-Saharan Africa: about 1,700 kilocalories per day (FAO)
- Kilocalories in one kilogram of corn: about 3,500

Note: You may express your answer as feeding one person over time (e.g., one tonne of corn could feed one person for a day/week/month/year) or as feeding multiple people for one day.

The United States consumes about 140 billion gallons of gasoline per year.[13] How much corn would it take to replace 100 percent of U.S. gasoline consumption with ethanol?

How many people would the quantity of corn in the previous question feed?

In 2010, the United States accounted for about 5.7 billion tonnes of carbon dioxide emissions—more than one-sixth of the world's total.[14] What percentage of U.S. carbon dioxide emissions would be eliminated if corn-based ethanol replaced gasoline?

Note, for comparison, that the Kyoto Protocol sets a target of reducing GHG emissions from industrialized countries by five percent against 1990 levels.

For discussion:

- Do you think that the United States should use corn as a fuel source, a food source, or some of each? Explain.
- Under what circumstances would you advocate for using corn only as a fuel source? Explain your reasoning.
- Under what circumstances would you advocate for using corn only as a food source? Explain your reasoning.
- What assumptions or simplifications did you make in the calculations above? Which do you think might be problematic? Explain.

13 Marzoughi, Hassan and P. Lynn Kennedy. 2012. The Impact of Ethanol Production on the U.S. Gasoline Market. Paper presented at the Southern Agricultural Economics Association Annual Meeting, Birmingham, AL, February 4–7, 2012.

14 Energy Information Administration, International Energy Agency

Lecture Summary, "Biofuels: The changing nature of agricultural demand"

The following news article summarizes a talk by Dr. Rosamond Naylor, a food policy and economics scholar with Stanford University's Center for Food Security and the Environment, on the topic of biofuels and their impacts on food security. As you read the summary, focus on the connections between Naylor's ideas and the material presented in this lesson. Use the questions in the Reading Guide to evaluate and reinforce your understanding of the key points.

April 18, 2012—*FSI Stanford, FSE News*

Biofuels have mixed impacts on food security, say FSE scholars

By Kate Johnson

In the first decade of the 21st century, global production of ethanol and biodiesel increased nearly tenfold. If that trend continues, says Dr. Rosamond Naylor, Director of Stanford University's Center on Food Security and the Environment, national biofuels policies will have an increasingly powerful impact on food prices, food security, energy security, and rural incomes in the developing world.

During a two-hour symposium held on the Stanford campus last Wednesday, Naylor addressed the role of biofuels in global food price volatility and the implications of biofuels development in rural Africa and Asia. Although she acknowledged that global income and population growth have contributed to increased demand for biofuels, she also emphasized "the unbelievable dominance of policy" in driving current trends.

"The main part of this that I think is so significant is the use of mandates," Naylor said. "Policies such as the United States' Renewable Fuels Standard (RFS), which sets a national target of using 15 billion gallons of corn-based ethanol per year by 2015, have reshaped price and supply dynamics in both food and fuel markets. "

mandate (biofuel)—a law or policy that requires production and/or use of a specific quantity or mixture of biofuels, usually on a national and annual basis. For example, the United States' Renewable Fuel Standard mandates that the U.S. consume 15 billion gallons of corn-based ethanol each year, starting in 2015

"When you think about the fact that the U.S. provides half of the world's corn … the fact that we're using so much in our gas tanks really is changing the nature of global markets," Naylor said. Policies that fix demand for corn from the ethanol market, she explained, have a destabilizing effect on corn prices, especially in the face of supply shortages.

"When you have mandates you have a quantity that you're absolutely insisting you use, regardless of the price," she said. "That inelastic demand leads to more volatile prices with supply shocks."

Because of the substitutability of basic food commodities, Naylor said, price volatility in the corn market has far-reaching consequences. "Prices of corn ripple through all of the world food economy markets … it affects the demand and supply of wheat and rice and soy, and other things," she explained. And for poor households in the developing world, she said, "it has big income effects … when you're spending 70 to 80 percent of your budget on food, you're going to be hurt the most."

However, Naylor also noted that biofuel mandates in the developed world could provide valuable market opportunities for developing-country farmers.

In rural Africa and Asia, she said, farmers "see the U.S. having a big mandate, EU having a big mandate, and they think, can they supply into that mandated need?"

For now, it seems, the answer is "maybe." In Africa, for example, efforts are underway to increase the use of jatropha—an inedible, drought-resistant shrub—as a biofuel feedstock. But Naylor said that low yields and high labor costs are likely to severely limit the economic returns from jatropha-based biofuels.

And in marginal growing conditions, the use of more conventional feedstocks is often restricted by resource availability. In India, for example, where almost all sugarcane is grown under irrigated conditions, expansion of sugarcane area to supply the ethanol market could lead to water shortages. Even if these countries can make large-scale biofuel production economically viable, the benefits to poor farmers could vary widely depending on the structure of the market.

"The implications of biofuel development are going to be quite different," Naylor said, "depending on the organization of the value chain."

Dr. Siwa Msangi, a Senior Research Fellow with the International Food Policy Research Institute, agreed. In comments following Naylor's presentation, Msangi said biofuel development contributes most effectively to rural income growth "when you can have vertical integration … people all along the value chain have to be making money."

Msangi also noted that commodity price increases, including those driven by ethanol mandates, could benefit small farmers if they are controlled and predictable. "Sharp, fast, sudden price rises—those are the ones that are bad for consumers," he explained. But prices rises "can be positive… especially if those price rises can be gradual and sustained over time, because that gives people the opportunity to mobilize resources to make use of higher returns." For example, small farmers at the local or national level can increase their production of crops in high demand for biofuel production.

The emerging connections between agriculture and energy markets are complex, Msangi said, but can be advantageous if handled carefully. "If there are good opportunities for agribusiness, I think there's a case for taking them," he said, "but also for being aware of the context and all the issues."

This was the eighth talk in FSE's Global Food Policy and Food Security Symposium Series.

Reading Guide: Lecture Summary, "Biofuels: The changing nature of agricultural demand"

The following questions are intended to help you focus on key ideas from the summary of Dr. Rosamond Naylor's lecture, "Biofuels: the changing nature of agricultural demand." Answer the questions in brief sentences as you read the summary; you may also wish to clarify or augment your answers by referring to other materials from this lesson.

1. By how much, according to the summary, did global biofuel production increase between 2000 and 2010?

2. Why does Naylor say that corn ethanol production in the U.S., in particular, has significant food security consequences?

3. What other food markets do corn prices affect and why?

4. From the perspective of a poor African farmer, what are the pros and cons of biofuel mandates in the developed world?

5. What problems does Naylor see with the development of:
   a. Jatropha biodiesel in Africa

   b. Sugarcane ethanol in India

6. Why, according to Dr. Siwa Msagni, are gradual increases in food prices better for small farmers than sudden increases?

7. Do you think that the overall food security effects of biofuel development will be positive or negative? Explain, using specific references to the statements in the summary (or to other materials in this lesson, as appropriate) to support your claims.

Teacher Information, Biofuel Feedstocks Fact Sheet

This fact sheet is intended to help instructors guide and assess student research during the group project. The information provided for each feedstock follows the project outline, answering several of the research questions listed in the student instructions. Instructors should be familiar with the fact sheet, including the resources listed below each feedstock, before assigning the project. In some cases, instructors may wish to provide the resources to students directly (in hard copy or as Internet links) to cut down on research time.

Notes on assigning feedstocks:

- Instructors with smaller classes may not wish to form a separate group for each feedstock. This sheet lists feedstocks in suggested order of priority for assignment.
- Because cellulosic ethanol and algae biodiesel are still in the experimental stage, students may not find detailed resources on the effects of biofuel production from these feedstocks. Therefore, instructors may wish to assign both feedstocks to a single group.
- Instructors with larger classes or who wish to form smaller groups may assign multiple groups to the same feedstock.

Sugarcane

- First-generation feedstock, used to produce ethanol
- Production is concentrated in Asia and the Americas; top global producers are Brazil, China, and India
- Sugarcane ethanol is produced primarily in Brazil, where it is the exclusive ethanol feedstock
- Production in Brazil is advanced, large-scale
- Comparatively small contributor to global calorie supply (according to FAO statistics, sugar accounts for only about 3 kcal/capita/day globally; for comparison, maize accounts for about 140 kcal/capita/day)
- Prices increased significantly in Brazil between 2000 and 2009, nearly doubling to a 20-year high of 18.5 $US per tonne
- Favorable energy balance (between 2.0 and 8.0)
- Requires high water inputs, but can be grown without irrigation in tropical high-rainfall areas (about 75 percent of Brazil's sugarcane production is rainfed)
- Expansion of cropland in Brazil (to increase soybean or sugar production for the biofuel market) may contribute to Amazon deforestation
- Large-scale production uses chemical fertilizers and pesticides

- Naylor, Rosamond. "Biofuels: the changing nature of agricultural demand." Lecture delivered at Stanford University, 11 April 2012
- Barros, Sergio. "Brazil Biofuels Annual." Global Agricultural Information Network Report Number BR10006. Sao Paulo: United States Department of Agriculture, 30 July 2010. Available online: http://gain.fas.usda.gov/Pages/Default.aspx (accessed 25 April 2012)
- U.N. Food and Agriculture Organization, "Biofuels: Prospects, risks, and opportunities," *The State of Food and Agriculture, 2008,* Rome: FAO, 2008. Available online: http://www.fao.org/publications/sofa/en/ (accessed 25 April 2012)
- United States Department of Agriculture. Crop Briefing Rooms: Sugar and Sweeteners. http://www.ers.usda.gov/Briefing SoybeansOilCrops/ (accessed 25 April 2012)

Corn

- First-generation feedstock, used to produce ethanol
- Grown throughout the world, and accounts for a significant share of calorie consumption in some developing regions (Africa, Latin America)
- Most corn ethanol is produced from the United States' domestic corn crop
- Corn ethanol production systems in the U.S. are large-scale and advanced
- The main by-product of corn ethanol production is dried distillers grain, a high-protein livestock feed
- About 40% of the U.S. corn crop went to produce ethanol in 2011, compared with about 10% in 2000
- The U.S. accounts for about 50% of global corn exports: Using U.S. corn for ethanol has significant effects on global food security
- US maize prices increased by about 75% between January 2005 and January 2010; although economists attribute the price spike to a combination of factors, demand for corn in the biofuel market has been repeatedly cited as one factor
- Corn ethanol production is an energy-intensive process, particularly in the U.S., where most corn is grown with the aid of fossil fuel–based fertilizers; energy balance between 1.0 and 2.0
- Can be grown under rainfed conditions; about 20% of U.S. maize area is irrigated

- Naylor, Rosamond. "Biofuels: the changing nature of agricultural demand." Lecture delivered at Stanford University, 11 April 2012
- U.N. Food and Agriculture Organization, "Biofuels: Prospects, risks, and opportunities," *The State of Food and Agriculture, 2008,* Rome: FAO, 2008. Available online: http://www.fao.org/publications/sofa/en/ (accessed 25 April 2012)
- United States Department of Agriculture. Crop Briefing Rooms: Sugar and Sweeteners. http://www.ers.usda.gov/Briefing SoybeansOilCrops/ (accessed 25 April 2012)

Rapeseed (canola) oil

- First-generation feedstock, used to produce biodiesel
- Largest producers are the European Union, Canada, China, India, and Australia
- Most rapeseed biodiesel is produced in the European Union: the EU converted about 7 million metric tons of rapeseed oil to biodiesel in 2011
- Production in the EU is advanced, large-scale
- Important food and feed source: third largest source of vegetable oil in the world (after soybean and palm) and second-largest source of feed meal after soybean
- As of 2008, about 60% of EU rapeseed production was used to produce biodiesel
- EU rapeseed prices rose sharply between 2004 and 2009 (according to FAO data, prices in Germany nearly doubled)
- Energy balance is between 1.0 and 4.0
- Fertilizer required for maximum yields, but can achieve high yields without irrigation

- Flach et al. "EU Biofuels Annual." Global Agricultural Information Network Report Number NL0019. The Hague: United States Department of Agriculture, 11 June 2010. Available online: http://gain.fas.usda.gov/Pages/Default.aspx (accessed 25 April 2012)
- Naylor, Rosamond. "Biofuels: the changing nature of agricultural demand." Lecture delivered at Stanford University, 11 April 2012
- U.N. Food and Agriculture Organization, "Biofuels: Prospects, risks, and opportunities," *The State of Food and Agriculture, 2008,* Rome: FAO, 2008. Available online: http://www.fao.org/publications/sofa/en/ (accessed 25 April 2012)
- United States Department of Agriculture. Crop Briefing Rooms: Soybeans and Oil Crops. http://www.ers.usda.gov/Briefing/SoybeansOilCrops/ (accessed 25 April 2012)

Soybean oil

- First-generation feedstock, used to produce biodiesel
- Grown primarily in Asia and the Americas (the U.S., Brazil, Argentina, China, and India are the top global soybean producers)
- Soy biodiesel production is concentrated in the U.S. and Brazil; roughly 80 percent of Brazil's biodiesel production used soybean oil as a feedstock in 2011
- Production in the U.S. and Brazil is advanced, large-scale
- Important fat and protein source in developing countries (Asia, Latin America)
- About 20% of the U.S. soybean crop and about 25% of the Brazil crop went to biodiesel production in 2011
- Important food and feed source: world's second-largest source of vegetable oil and largest source of livestock feed meal
- The U.S. is the world's largest producer and exports over 50% of production, accounting for over one-third of global soybean exports
- U.S. price increased by over 80% between January 2005 and January 2010
- Energy balance between 1.0 and 3.5
- High pesticide (herbicide) applications
- Expansion of cropland in Brazil (to increase soybean or sugar production for the biofuel market) may contribute to Amazon deforestation
- Minimal water requirements (only 8% of U.S. soybean acreage is irrigated)
- Nitrogen-fixing; minimal fertilizer requirements

- Barros, Sergio. "Brazil Biofuels Annual." Global Agricultural Information Network Report Number BR10006. Sao Paulo: United States Department of Agriculture, 30 July 2010. Available online: http://gain.fas.usda.gov/Pages/Default.aspx (accessed 25 April 2012).
- Naylor, Rosamond. "Biofuels: the changing nature of agricultural demand." Lecture delivered at Stanford University, 11 April 2012
- U.N. Food and Agriculture Organization, "Biofuels: Prospects, risks, and opportunities," *The State of Food and Agriculture, 2008,* Rome: FAO, 2008. Available online: http://www.fao.org/publications/sofa/en/ (accessed 25 April 2012)
- United States Department of Agriculture. Crop Briefing Rooms: Sugar and Sweeteners. http://www.ers.usda.gov/Briefing SoybeansOilCrops/ (accessed 25 April 2012)

Palm oil

- First-generation feedstock, used to produce biodiesel
- Produced primarily in Asia; largest producers are Indonesia and Malaysia
- Most palm oil biodiesel is produced in Indonesia, which has strong biofuel incentive policies; USDA forecasts suggest that Indonesia produced about 170 million gallons of biodiesel in 2011, with palm oil as the primary feedstock
- Important food source; accounts for about one-fifth of the global edible oil market
- Global prices more than doubled between January 2005 and January 2010
- Palm oil production in southeast Asia has been associated with deforestation (often accomplished through burning, which contributes to greenhouse gas emissions) and heavy applications of chemical fertilizer
- Due to environmental downsides (deforestation, fertilization) palm oil biodiesel does not meet requirements for U.S. and EU biofuel mandate programs

- Palm oil biodiesel has a favorable energy balance (8.0–10.0); higher than for other biodiesel feedstocks because palm oil can be extracted without crushing the seeds, a high-energy process

- Naylor, Rosamond. “Biofuels: the changing nature of agricultural demand.” Lecture delivered at Stanford University, 11 April 2012
- Slette, John and Ibnu Edy Wiyono. “Indonesia Biofuels Annual.” Global Agricultural Information Network Report Number ID1134. Jakarta: United States Department of Agriculture, 19 August 2011. Available online: http://gain.fas.usda.gov/Pages/Default.aspx (accessed 25 April 2012)
- Rosenthal, Elisabeth. “Once a Dream Fuel, Palm Oil May Be an Eco-Nightmare.” *The New York Times*, 31 January 2007
- U.N. Food and Agriculture Organization, “Biofuels: Prospects, risks, and opportunities,” *The State of Food and Agriculture, 2008, Rome: FAO, 2008*. Available online: http://www.fao.org/publications/sofa/en/ (accessed 25 April 2012)

Jatropha

- First-generation feedstock, used to produce biodiesel
- Grows in tropical and subtropical regions, including many developing African and Southeast Asian countries
- Jatropha biodiesel production is in the experimental stage; limited pilot projects have occurred in Indonesia
- Inedible; biofuel production from jatropha is not a threat to global food supplies
- Drought resistant, but yields are low without irrigation and fertilizer
- High labor costs (harvesting jatropha seeds is labor-intensive); provides rural job opportunities, but makes biofuel production less economically viable

- Naylor, Rosamond. “Biofuels: the changing nature of agricultural demand.” Lecture delivered at Stanford University, 11 April 2012
- Slette, John and Ibnu Edy Wiyono. “Indonesia Biofuels Annual.” Global Agricultural Information Network Report Number ID1134. Jakarta: United States Department of Agriculture, 19 August 2011. Available online: http://gain.fas.usda.gov/Pages/Default.aspx (accessed 25 April 2012)
- U.N. Food and Agriculture Organization, “Biofuels: Prospects, risks, and opportunities,” *The State of Food and Agriculture, 2008, Rome: FAO, 2008*. Available online: http://www.fao.org/publications/sofa/en/ (accessed 25 April 2012)

Cellulosic feedstocks

- Second-generation feedstocks, used to produce ethanol
- “Cellulosic” refers to the cellulose-based cell walls of any green plant; this cellulose can be converted to sugar, which is in turn fermented into fuel. The first stage of this process is technically difficult.
- Possible cellulosic feedstocks include fast-growing trees, grasses, and agriculture and forestry residues
- Cellulosic ethanol production is in the pilot phase; development of commercial-scale facilities is under way in a few developed countries
- Inedible feedstocks do not compete with food supplies
- Many cellulosic feedstocks can grow on marginal land with minimal inputs, improving the resource efficiency of biofuel production
- Removing large quantities of biomass residue from agriculture and forestry systems could negatively effect food security
- Energy balance of at least 2; could be >10 depending on feedstocks and production technology

- Naylor, Rosamond. "Biofuels: the changing nature of agricultural demand." Lecture delivered at Stanford University, 11 April 2012
- Renewable Fuels Association, "Advanced Ethanol," http://www.ethanolrfa.org/pages/advanced-ethanol (accessed 25 April 2012)
- UN Food and Agriculture Organization, "Biofuels: Prospects, risks, and opportunities," *The State of Food and Agriculture, 2008*, Rome: FAO, 2008. Available online: http://www.fao.org/publications/sofa/en/ (accessed 25 April 2012)

Algae

- Third-generation feedstock, used to produce biodiesel
- Production is in the experimental stage; ultimately, strains of algae selected and bred for fast growth and high lipid (fat) content would be grown and harvested for biodiesel production
- Would not compete with food crops for land or fresh water

- Naylor, Rosamond. "Biofuels: the changing nature of agricultural demand." Lecture delivered at Stanford University, 11 April 2012
- Wagner, Leonard. Biodiesel from algae oil. Mora Associates, July 2007. Available online from www.fao.org (accessed 25 April 2012)

Price, production, and food supply data from the following sources (accessed 23–25 April 2012):

- USDA Production, Supply, and Distribution online database: http://www.fas.usda.gov/psdonline/psdQuery.aspx
- FAOSTAT online database: faostat.fao.org
- International Monetary Fund online eLibrary statistics (price data): elibaray-data.imf.org

Answer Key to Handout 1 (Introduction to Biofuels)

1. By how much did global biofuel production (ethanol and biodiesel combined) increase between 2000 and 2010? Express your answer as a percentage.

   Biodiesel production in 2000 =~ 20,000 barrels per day

   Ethanol production in 2000 =~ 300,000 barrels per day

   Total in 2000 =~ 320,000 barrels per day

   Biodiesel production in 2010 =~340,000 barrels per day

   Ethanol production in 2010 =~ 1,500,000 barrels per day

   Total in 2010 =~ 1,840,000 barrels per day

   Percentage increase = (1,840,000 – 320,000) / 320,000 = 4.75

   Total production increased by 475%

2. In 2010, what fraction of the total volume of biofuel produced was biodiesel? Ethanol?

   The total volume produced in 2010 was about 1,840,000 barrels per day (see above), of which about 340,000 barrels per day were biodiesel. The fraction that was biodiesel is therefore 340/1840 = or a little less than one-fifth. The remaining four-fifths of the total production was ethanol.

3. Which country was the largest single producer of ethanol in 2000? In 2010?

   2000: Brazil

   2010: United States

4. Which country or countries produced the majority of the world's biodiesel in 2010?

   Europe (note: The top four European biodiesel producers in 2010 were, in order, Germany, France, Spain, and Italy)

5. Which of the following experienced the largest net growth between 2005 and 2010?
   a. Biodiesel production in Europe
   b. Biodiesel production outside Europe, the U.S., and Brazil
   c. Ethanol production in the United States (an increase of about 600,000 barrels per day)
   d. Ethanol production in Brazil

For discussion:

- How would you characterize the major biofuel-producing countries with respect to economic and agricultural development?

  Students should note that all of these countries are relatively wealthy and have highly productive agricultural sectors. Although Brazil is more often described as an "economy in transition" (as opposed to a "developed" or "advanced" economy), its position as a top global producer of several food commodities (including biofuel feedstocks such as corn, sugarcane, and soybeans) gives it standing alongside the U.S. and Europe in this context.

- What biofuel feedstocks do you think might be used in these countries?

  If students completed Lesson Two, they should recall that both the United States and Brazil are major producers of maize (corn), a common ethanol feedstock. In fact, almost all U.S. ethanol (about 97 percent) is produced from corn—Brazilian ethanol, however, is produced primarily from sugarcane. Brazil is the world's top producer of sugarcane.

  In Europe, biodiesel is produced from various oil crops—primarily rapeseed (which is also used to make canola oil), palm, and soy. The 27 countries of the European Union collectively represent about 30 percent of the world's total rapeseed production. In the U.S. and Brazil, soybeans are the most prevalent and promising biodiesel feedstock—the U.S. is the world's top soybean producer, representing about one-third of global production, while Brazil is second, with about 40 percent of the remaining crop.[9]

- Which countries might be included in the "other" bar on each graph? Do you think that these countries use the same feedstocks as the major producers? Explain your answer.

  Students should recognize that the "other" bar probably includes developing countries with smaller economies and less-advanced agricultural sectors. Some of these countries will use the same feedstocks as large producers—students who completed Lesson Two may recall, for example, that maize is grown throughout the world and could be used as a feedstock in nearly any country. However, many smaller producers will also use crops that are particularly well adapted to the local climate or that have historically been a cultural part of the food system. Indonesia, for example, produces about half of the world's palm oil, with about one-tenth of the crop currently used to produce biodiesel.[10]

9 Data from USDA Production, Supply, and Demand online database, accessed 19 April 2012
10 USDA Foreign Agricultural Service, Indonesia Biofuels Annual (2011)

Answer Key to Handout 3 (Activity, One Tonne of Corn)

In this activity, you will consider the effects of using corn as a fuel source. Replacing gasoline with corn-based ethanol reduces greenhouse gas emissions, but also restricts the quantity of corn available for human consumption. But how much does the it conversion of corn to fuel really affect the environment and the food supply? The questions below will help you quantify the pros and cons. After answering the questions, you will discuss the tradeoffs with your classmates.

For simplicity, we will assume that one gallon of 100 percent corn-based ethanol replaces an energy-equivalent volume of 100 percent gasoline. In reality, ethanol and gasoline are usually combined in varying ratios to create fuel blends, sometimes called *gasohol*. The gas you buy today probably has at least some ethanol in it already. Ethanol has been blended into gasoline at rates of up to 10 percent since 2005; the resulting fuel burns cleaner than pure gasoline, reducing air pollution.

We will also assume that producing and burning one gallon of corn ethanol reduces greenhouse gas emissions by about 15 percent compared with producing and burning one gallon of gasoline. This estimate, which is based on the U.S. Environmental Protection Agency's Life Cycle Analysis of Greenhouse Gas Emissions from Renewable Fuels,[9] takes into account the fossil fuel energy used in corn farming and ethanol production. The exact reduction in emissions varies, depending on farm practices and the efficiency of the technology used by the ethanol plant.

You may need a calculator. You'll also need to use the following conversions throughout the exercise:

One tonne (metric ton) = 1,000 kg

One tonne of corn = 39.4 bushels

How many tonnes of carbon dioxide emissions are avoided by converting one tonne of corn to ethanol?

Use the following information (and the assumptions and conversions above):

- One bushel of corn = 2.7 gallons of ethanol.[10]
- Ethanol is about 70 percent as efficient as gasoline (i.e., 10 gallons of ethanol can replace one gallon of gasoline).[11]
- Burning one gallon of gasoline releases about 8.9 kilograms of carbon dioxide into the atmosphere.[12]

$$\textit{1 tonne corn} * \frac{\textit{39.4 bushels}}{\textit{tonne corn}} * \frac{\textit{2.7 gallons ethanol}}{\textit{bushel}} * \frac{\textit{0.7 gallons ethanol}}{\textit{gallon gasoline}} = \frac{\textit{74.5 gallons gasoline}}{\textit{tonne corn}}$$

$$\textit{74.5 gallons gasoline} * \frac{\textit{8.9 kg CO2}}{\textit{gallon gasoline}} * \frac{\textit{1 tonne CO2}}{\textit{1000 kg CO2}} = \textit{0.66 tonne CO2}$$

9 http://www.epa.gov/otaq/renewablefuels/420f09024.htm
10 USDA, "Ethanol Reshapes the Corn Market," *Amber Waves*, April 2006
11 Energy Information Administration
12 U.S. EPA Greenhouse Gas Equivalencies Calculator, http://www.epa.gov/cleanenergy/energy-resources/calculator.html, accessed 19 April 2012

How many people can one tonne of corn feed?

Use the following information:

- Minimum Dietary Energy Requirement for sub-Saharan Africa: about 1,700 kilocalories per day (FAO)
- Kilocalories in one kilogram of corn: about 3,500

Note: You may express your answer as feeding one person over time (i.e. one tonne of corn could feed one person for a day/week/month/year) or as feeding multiple people for one day.

$$\frac{3500\ kcal}{kg\ corn} * \frac{1000\ kg}{tonne} = \frac{3{,}500{,}000\ kcal}{tonne\ corn}$$

$$\frac{3{,}500{,}000\ kcal}{tonne\ corn} * \frac{1\ person\_day}{1700\ kcal} = 2{,}058\ person\_days$$

One tonne of corn can feed one person for 2,058 days (5.6 years), or 2,058 people for one day.

The United States consumes about 140 billion gallons of gasoline per year.[13] How much corn would it take to replace 100 percent of U.S. gasoline consumption with ethanol?

Using results from the first question:

$$140\ billion\ gallons\ gasoline * \frac{1\ gallon\ ethanol}{0.7\ gallons\ gasoline} = 200\ billion\ gallons\ ethanol$$

$$200\ billion\ gallons\ gasoline * \frac{1\ tonne\ corn}{106.4\ gallons\ ethanol} = 1.9\ billion\ tonnes\ corn$$

How many people would the quantity of corn in the previous question feed?

Using results from the first question:

$$1.9\ billion\ tonnes\ corn * \frac{2{,}058\ person\_days}{tonne\ corn} = 3.7\ trillion\ person\_days$$

1.9 billion tonnes of corn would feed 3.7 trillion people for one day (more than 500 times the population of the world) or one person for 3.7 trillion days (more than a billion years).

13 Marzoughi, Hassan and P. Lynn Kennedy. 2012. The Impact of Ethanol Production on the U.S. Gasoline Market. Paper presented at the Southern Agricultural Economics Association Annual Meeting, Birmingham, AL, February 4–7 2012.

In 2010, the United States accounted for about 5.7 billion tonnes of carbon dioxide emissions —more than one-sixth of the world total.[14] What percentage of U.S. carbon dioxide emissions would be eliminated if corn-based's ethanol replaced gasoline?

Using results from the first and third questions:

$$\text{1.9 billion tonnes corn} * \frac{\text{0.66 tonne CO2 reduced}}{\text{tonne corn converted}} = \text{1.25 billion tonnes CO2 reduced}$$

$$\frac{\text{1.2 billion tonnes CO2}}{\text{5.7 billion tonnes CO2}} = 0.22$$

About 22 percent.

Note, for comparison, that the Kyoto Protocol sets a target of reducing GHG emissions from industrialized countries by five percent against 1990 levels.

For discussion:

- Do you think that the United States should use corn as a fuel source, a food source, or some of each? Explain.
- Under what circumstances would you advocate for using corn only as a fuel source? Explain your reasoning.
- Under what circumstances would you advocate for using corn only as a food source? Explain your reasoning.
- What assumptions or simplifications did you make in the calculations above? Which do you think might be problematic? Explain.

  Note: in addition to the assumptions listed in the introduction, students should note that humans need a variety of foods – we cannot survive on a diet composed entirely of corn.

14 Energy Information Administration, International Energy Agency

Answer Key to Handout 5 (Reading Guide: Lecture Summary, "Biofuels: The changing nature of agricultural demand")

1. By how much, according to the summary, did global biofuel production increase between 2000 and 2010?

   Production increased "nearly tenfold."

2. Why does Naylor say that corn ethanol production in the U.S., in particular, has significant food security consequences?

   The US "provides half the world's corn" (half of all corn exports originate from the U.S.).

3. What other food markets do corn prices affect and why?

   Changes in the corn price affect the prices of substitute food staples such as rice, wheat, and soy.

4. From the perspective of a poor African farmer, what are the pros and cons of biofuel mandates in the developed world?

   Cons: Increased demand for staple foods (corn, soy, etc.) drives up prices.

   Pros: Poor farmers may be able to profit from selling crops to biofuel producers.

5. What problems does Naylor see with the development of:

a. Jatropha biodiesel in Africa

   Although jatropha is inedible (and thus biofuel production would not compete with food supplies) and drought-resistant, it is a labor-intensive crop and yields are poor in marginal conditions without irrigation or fertilizers.

b. Sugarcane ethanol in India

   Almost all Indian sugarcane is irrigated; expansion of sugarcane production could strain water supplies.

6. Why, according to Dr. Siwa Msagni, are gradual increases in food prices better for small farmers than sudden increases?

   If price increases are gradual, farmers can "mobilize resources" and adapt (e.g., by planting more corn) if corn prices go up due to demand from ethanol producers. If prices increase suddenly, however, farmers have to pay more for food but may not have the correct products on hand to benefit from sales.

7. Do you think that the overall food security effects of biofuel development will be positive or negative? Explain, using specific references to the statements in the summary (or to other materials in this lesson, as appropriate) to support your claims.

   Student answers will vary. Excellent responses will

   - *take a clear position on the question (i.e., the overall impacts will be positive/negative);*
   - *refer to facts or quotes from the lecture summary to support the position;*
   - *make meaningful connections between the summary and other lesson materials; and*
   - *use appropriate vocabulary from the lesson.*

Lesson Six

Emerging Food Security Challenges
Part Two: Climate and Agriculture

Organizing Questions

- How do scientists expect Earth's climate to change during the next century?
- How will projected changes in Earth's climate affect agricultural productivity and global food security?
- What adaptation strategies will most effectively minimize the food security impacts of future climate change?

Introduction

In this lesson, students explore interactions between food security and global climate, focusing on projected 21st-century climate change and its effects on food security. The lesson draws on selections from a lecture by Stanford University professor David Lobell, whose work focuses on the impacts of climate on agriculture. Lobell's lecture outlines expected 21st-century climate trends in the context of current limits on the accuracy of scientific forecasts, explains the effects of temperature and precipitation affect crop productivity, and explore various strategies for minimizing the effects of future climate change on food security. The lesson concludes with a writing exercise that asks students to weigh the pros and cons of these strategies and to select a particular set of strategies to support and defend.

Objectives

In this lesson, students will

- appreciate both the certainties and uncertainties of climate change forecasts;
- learn how temperature and precipitation affect crop productivity;
- explore and explain variation in the projected effects of climate change across geographical regions and crop systems;
- weigh the pros and cons of different climate change adaptation strategies; and
- weigh the significance of climate change as an obstacle to food security, relative to other obstacles discussed in the unit.

Materials

- Handout 1, *Introduction to Climate Change Science*
- Handout 2, *Viewing Guide: Lobell Lecture Clip, Impacts of Climate on Agriculture*
- Handout 3, *Viewing Guide: Lobell Lecture Clip, Climate Change Adaptation Strategies*
- Handout 4, *Assignment: Climate Policy Essay Assignment*

- Handout 5, *Quiz*
- (Optional) Handout 6, *Climate Change News Analysis Assignment*
- DVD, clips from David Lobell, *"Climate Change and Agricultural Adaptation."* Lecture delivered at Stanford University, December 8, 2011. Complete lecture available online – instructor may choose to show additional content or to make the entire video available to students outside of class.
- Answer Key, *Introduction to Climate Change Science*
- Answer Key, *Viewing Guide: Lobell Lecture Clip, Impacts of Climate on Agriculture*
- Answer Key, *Viewing Guide: Lobell Lecture Clip, Climate Change Adaptation Strategies*
- Answer Key, *Quiz*
- Supplementary Material 1, *Variability and Change*
- Supplementary Material 2, *Lobell Lecture Summary*

Equipment

- Video projector and DVD player

Teacher Preparation

1. Review Handouts 1, 2, 3, and 5, and make the appropriate number of copies (one per student).
2. Review Handouts 4 and 6 (directions for the *Climate Policy Essay* and *Climate Change News Analysis* assignments). Determine which combination of assignments (none, one, or both) will be most appropriate for the class. Make the appropriate number of copies of the selected assignment(s) (one per student).
3. Review Supplementary Material 1, *Variability and Change*, and Supplementary Material 2, *Lobell Lecture Summary*, and determine whether these materials are appropriate for the class. Make the appropriate number of copies of selected supplementary materials.
4. Highly recommended: View David Lobell's lecture, "Climate Change and Agricultural Adaptation" in its entirety (available online). Lobell's speaking style is highly accessible, and his lecture should help instructors familiarize themselves with the lesson material. Instructors may also wish to direct advanced students to additional lecture excerpts online or to show additional lecture material in class.
5. Before Day One, set up and test video projection equipment.
6. Before Day Two, arrange the room for group work.

Time

The complete lesson requires at least two 50-minute class periods. Students also complete a homework assignment prior to Day One. Options for extending or shortening the lesson are provided in the Extensions and Excerpts section, below.

Procedures Before Day One

Inform students that they will be learning about global climate change and its effects on agriculture and food security. Distribute one copy each of Handouts 1, 2, and 3 to each student. Explain that the reading and exercises in Handout 1 (*Introduction to Climate Change Science*) will introduce them to some basic principles of climate science. Ask students to read this handout carefully and to complete the exercises before the beginning of the next class period. Handouts 2 and 3 (*Viewing Guide: Lobell Lecture Clip, Impacts of Climate on Agriculture and Viewing Guide: Lobell Lecture Clip, Climate Change Adaptation Strategies*) will be used during the next class period. Students should review the guide before the next class period, so that they are prepared to focus on the most important information in the video.

Day One

1. (10 minutes) Ask students to take out their completed copies of Handout 1. Review the following points with students:

- What three aspects of future climate change can scientists predict with relative certainty?

  Global average temperature will increase; precipitation intensity will increase; dry areas will become drier. Discuss the major reasons for these changes (the greenhouse effect; warm air holds more water vapor).

- What three aspects of future climate change are more difficult to predict?

  Changes in local rainfall patterns; the precise rate of temperature increase; changes in year-to-year or season-to-season climate variability. Emphasize that climate forecasts are more reliable at larger spatial and temporal scales; note that these uncertainties make it difficult to predict the frequency of extreme events:

- Which countries or regions will be most heavily affected by
  - o increased temperature
    High latitudes—the poles—will experience the greatest net increases in temperature, but the tropics will experience a greater increase in the frequency of temperature extremes.
  - o heavier rainfall
    High latitudes and the equator (many areas that already experience heavy rainfall, e.g., tropical rainforests).
  - o decreased soil moisture
    Mid latitude arid regions: Northern and southern African deserts, southern Europe, southern U.S. and Central America, Australia, southeast South America

2. (5 minutes) Ask students to take out Handout 2. Explain that they will now watch a clip from David Lobell's lecture on agriculture and climate change. The clip is about 20 minutes in length. Instruct students to take notes on their handouts while they watch the clip.
3. (20 minutes) Show the first clip from Lobell's lecture.
4. (5 minutes) Ask students to respond to the following general question, drawing on the material in the clip:

How will projected climate change affect global agricultural productivity in the 21st century? How will climate change affect food security? Students should recognize that the overall effect on productivity will be negative (in the absence of adaptation), and that some of the largest effects will be in regions that are already food insecure.

Inform students that they will now watch the second clip from Lobell's lecture, which discusses strategies to minimize the negative food security impacts of climate change. Ask students to take out Handout 3, and to take notes on the viewing guide as they watch the clip. This clip is less than five minutes in length.

5. (5 minutes) Show the second clip from Lobell's lecture (51:00–53:00).
6. (5 minutes) Briefly clarify with students the distinction between "reliance-improving" and "impact avoiding adaptation strategies (see the Answer Key to Handout 3 for appropriate definitions and examples). Distribute one copy of Handout 4, *Climate Policy Essay Assignment,* to each student. Explain to students that for homework, they will write an essay that compares the effectiveness of resilience-improving and impact-avoiding adaptation strategies. If time allows, students should review the assignment and ask any questions.
7. At the end of class, ask students to complete the essay assignment and to refine their answers on the two video viewing guides before the next class period. Direct students to the following supplementary resources (in hard copy or online):
   - Full-length Lobell lecture (online)
   - Supplementary Material 1, *Variability and Change*
   - Supplementary Material 2, *Lobell Lecture Summary*

Students may find these resources useful as they craft their essays and refine their answers on the viewing guides.

Note: Instructors may choose to assign the *Climate Change News Analysis* assignment in lieu of the *Climate Policy Essay* assignment. Distribute one copy of Handout 6, *Climate Change News Analysis Assignment,* to each student, and ask students to complete the assignment before the next class period.

Day Two

1. (15 minutes) Inform students that they will be taking a short quiz on the material covered in Handout 1 and the first clip from Lobell's lecture. Distribute one copy of Handout 5, *Quiz*, to each student. Give students about 15 minutes to work silently on the quiz. Collect the quizzes for evaluation after 15 minutes.
2. (5 minutes) Ask students to take out their completed essays. Divide the class into two groups: those who argued in favor of resilience-improving adaptation strategies, and those who argued in favor of impact-avoiding strategies. Form groups of two or three students within these larger groups.

3. (10 minutes) Instruct students to share the main points in their essays with their groups. Inform the groups that they will be defending their chosen strategies against an opposing group later in the period.
4. (10 minutes) Pair each resilience-improving group with an impact-avoiding group. Ask the group to discuss to conduct a mini debate using the following format:
   a. Each group presents an argument for its strategy (two minutes per group).
   b. Impact avoiders present specific challenges to the resilience-improver argument (one minute); resilience improvers respond (one minute).
   c. Resilience improvers present specific challenges to the impact-avoider argument (one minute); impact avoiders respond (one minute).
   d. As a group, discuss the merits of both arguments.
5. (10 minutes) Bring the class back together and lead a class discussion on the essay assignment. Ask students to respond to the following questions:
   - What were the main arguments made by the resilience improvers?
   - What were the main arguments made by the impact avoiders?
   - Did anyone change his or her mind? If so, in which direction and why?
   - What arguments might be made for pursuing hard strategies over soft strategies or vice versa? Planned strategies over autonomous strategies or vice versa?
5. If any time remains in the period, allow students to spend a few minutes finalizing their work on the lesson handouts. At the end of the period, collect Handouts 1, 2, and 3, and the essay assignment, for evaluation.

   Note: If students completed the *Climate Change News Analysis* assignment, use the latter part of Day Two to discuss the news articles, first in small groups and then as a class. Consider the following procedure:
   1. In small groups, ask students to share their article source, topic, and main points. Also ask students to discuss whether they felt their article effectively conveyed key effects and adaptation strategies, and why. Did they learn anything new from the article? Did they feel that the author omitted any important facts or details?
   2. As a class, have a few students share the details of their articles, and then discuss the general profile of news coverage on this topic:
      a. Do certain regions or crops seem to receive more coverage than others? Why might this be the case?
      b. Do certain adaptation strategies seem to receive more coverage than others? Why might this be the case?
      c. Are climate effects on agriculture portrayed by the media as an urgent or important problem? Why or why not?

Extensions and Excerpts

Extensions: instructors may choose to have students complete both the *Climate Policy Essay* and *Climate Change News Analysis* assignments. Distribute the first assignment as homework at the end of Day One and the second assignment at the end of Day Two (the assignments may be completed in any order). If time allows, use a third class period to discuss the second assignment.

The materials for this lesson also include two supplementary readings: a news summary of David Lobell's lecture and a selection from Lobell's paper that describes the distinction between climate change and climate variability. Instructors may assign or distribute these readings at any point during the lesson. The readings should be accessible for most students and may help some students improve their understanding of the content of the lecture video.

If students express particular interest in the topic, instructors may wish to direct them to the Web site of the Intergovernmental Panel on Climate Change (www.ipcc.ch), where they will find the most authoritative data and reports on global climate change and its effects.

Excerpts: Instructors with less time to devote to the lesson may omit the writing assignments, concluding the lesson with the quiz or a brief class discussion at the beginning of Day Two.

Assessment

The following are suggestions for assessing student work in this lesson:

- Assess Handout 1, *Introduction to Climate Change Science,* based on accuracy and completeness of student responses to the graph analysis questions (use the Answer Key as a guide)
- Assess Handout 2, *Viewing Guide: Lobell Lecture Clip, Impacts of Climate on Agriculture,* based on accuracy and completeness of student responses to the graph analysis questions (use the Answer Key as a guide)
- Assess Handout 3, *Viewing Guide, Lobell Lecture Clip, Climate Change Adaptation Strategies,* based on accuracy and completeness of student responses to the graph analysis questions (use the Answer Key as a guide)
- Assess the *Climate Policy Essay* assignment based on the following criteria:
  - o Content
    - Does the student adopt and defend a clear stance?
    - Does the student respond to a majority of the questions listed in the assignment handout?
    - Does the student's argument demonstrate a clear understanding of the distinctions between resilience-improving and impact-avoiding adaptation strategies?
    - Does the student also discuss and demonstrate a clear understanding of the distinctions between hard and soft, and planned and autonomous, adaptation strategies?

    - Does the student's argument relate the challenge of climate change to other food security issues covered in this unit?
    - Does the student support points with specific references to the lesson and unit materials, rather than relying solely on his or her own opinions and experiences?
  - o Style
    - Is the essay logically organized and easy to follow? Does the student include a clear introduction, thesis, and conclusion?
    - Does the student correctly employ unit vocabulary?
    - Does the student use correct spelling and grammar?
    - Does the essay adhere to the suggested word limit?
- Assess Handout 5, *Quiz*, based on accuracy and completeness of student responses, using the Answer Key as a guide
- (Optional) Assess Handout 6, *Climate Change News Analysis Assignment,* based on the following criteria:
  - o Content
    - Has the student chosen a relevant article from an appropriate source?
    - Does the review essay include an accurate, concise summary of the article's focus and key messages?
    - Does the student connect the material in the article to the concepts covered in this lesson, using specific reference and quotes as appropriate?
    - Does the student demonstrate, in the context of the article, a clear understanding of the following concepts?
      - Future climate trends
      - Relative certainty of different climate forecasts
      - Effects of climate on agriculture, including variation across regions and crops
      - Range and classification of strategies for adapting agriculture to climate change
    - Does the review essay include a balanced, thoughtful summary of the student's overall impression of the article?
  - o Style
    - Is the review essay logically organized and easy to follow? Does the student include a clear introduction, thesis, and conclusion?
    - Does the student correctly employ unit vocabulary?
    - Does the student use correct spelling and grammar?
    - Does the essay adhere to the suggested word limit?
- Assess the student's contributions to group work and class discussion based on
  - o accuracy and appropriateness of contributions;
  - o clear and succinct statement of comments, questions, and answers;

- attention to other students' questions and ideas;
- ability to follow and promote lively, productive discussion;
- open-mindedness and respect for other students' backgrounds and opinions;
- willingness and ability to compromise and incorporate other students' ideas when drawing conclusions as a group or producing a group product; and
- willingness and ability to express confusion and request clarification from other students and the instructor.

Introduction to Climate Change Science

greenhouse gasses—atmospheric gasses that absorb outgoing radiation emitted from the Earth's surface and re-emit part of it back towards the surface, producing insulating and heating effects

General Circulation Models, or GCMs—numeric computer representations of physical processes in the atmosphere, ocean, cryosphere (ice sheets), and land surface. GCMs depict the climate at a relatively coarse scale, using a 250–600 km grid over land surfaces and wide layers in the atmosphere and oceans. Thus, they cannot make reliable projections for local areas. Despite their limitations, however, GCMs are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations. (Adapted from IPCC, "What is a GCM?" http://www.ipcc-data.org/ddc_gcm_guide.html)

Intergovernmental Panel on Climate Change—the leading international body for the assessment of climate change. Formed in 1990 by the United National Environment Programme and the World Meteorological Society, the IPCC is a scientific organization that reviews and assesses the most recent scientific, technical and socio-economic information produced worldwide relevant to the understanding of climate change. Thousands of scientists worldwide contribute to the work of the IPCC on a voluntary basis

Underlying any prediction of climate change are a couple of basic physical principles, both of which have been known for more than 100 years.

First, gases such as carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O) [all of which are produced from human activities such as fossil fuel combustion, industrial agriculture, and livestock operations] *absorb outgoing radiation emitted from the Earth's surface and re-emit part of it back towards the surface, much like a blanket keeps warm air from escaping. Raising the concentration of these greenhouse gases therefore leads to an increase in energy within the Earth's atmosphere, reflected in an increase in global temperatures (i.e. the greenhouse effect).*

Second, the amount of water vapor that air can hold increases exponentially with air temperature, so that a world with higher average temperature will tend to have more water vapor (itself a greenhouse gas).

These and other physical principals form the core of general circulation models (GCMs), which are used to project future changes in climate.

- Lobell, David. "Climate Change and Agricultural Adaptation." Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century. Stanford: Center on Food Security and the Environment. December 8, 2011.

In this lesson, you will explore the food security effects of projected changes in global climate. The lesson is not intended to serve as a comprehensive overview of climate science; indeed, such an overview would fill many volumes. However, you will find it useful to understand a few key aspects of the science (including those summarized in the quote above, from research conducted by experts in climate and agriculture at Stanford University) as you consider the consequences for poverty, hunger, and agricultural productivity. This handout summarizes the most important principles and projections.

What we know about future climate change

Since 1990, when the Intergovernmental Panel on Climate Change (IPCC; www.ipcc.ch) issued its First Assessment Report on Climate Change, scientists have made great progress in understanding the past, present, and future effects of human activity on Earth's climate system. Although the science remains complex, we can now project certain future changes with relative certainty. The following generally agreed-upon forecasts have particular relevance for agriculture and food security:

1. Global temperatures will continue to increase.

   Scientists expect global mean temperatures to increase by about 0.2°C per decade until the year 2050. Because this average increase includes temperature changes in the Earth's oceans, which are expected to warm more slowly than the continents, the average change in areas inhabited by humans (including all agricultural regions) will likely be closer to 0.3–0.4°C.

As average temperature increases, extreme heat events (e.g., heat waves and record-breaking hot days and nights) are expected to become more frequent, while extreme cold events will become less frequent.

2. Heavier rainfall events will become more common.

   Think of the Earth's atmosphere as a "bucket" that carries water vapor from place to place. As the air warms (see no. 1, above), the bucket expands; simply put, more liquid water will evaporate to become water vapor when the air is warmer. The larger bucket may empty no more frequently than before, or even less frequently, but when it does so, the resulting rainfall events will be much more dramatic. The result is an increase in global average precipitation intensity: the total amount of rainfall (measured in inches) divided by the total number of rainy days.

precipitation intensity—a measure of the average "heaviness" of rainfall events: total rainfall divided by total number of rainy days

3. Dry regions will become drier.

   As the atmospheric "bucket" expands in size, it dumps more water in regions where climatic conditions favor rainfall (tropics and temperate zones); but it also carries more water away from regions where climatic conditions favor evaporation (deserts). Thus, water availability in historically dry regions is likely to decline even further with future climate change.

4. Climate change will not affect all regions equally or in the same ways.

   Study the maps on the next page, and answer the following questions:

   a. Which global regions experienced the greatest net increase in July temperatures between 1980 and 2010? Which regions have experienced the least increase (or the greatest decrease)?

      Greatest increase:

      Least increase:

   b. Which global regions are expected to experience the greatest percentage increase in extreme summer temperatures between 2009 and 2050? Which regions are expected to experience the least increase (or the greatest decrease)?

      Greatest increase:

      Least increase:

   c. Which global regions are expected to experience the greatest increase in precipitation intensity between 1980 and 2080? Which regions are expected to experience the least increase (or the greatest decrease)?

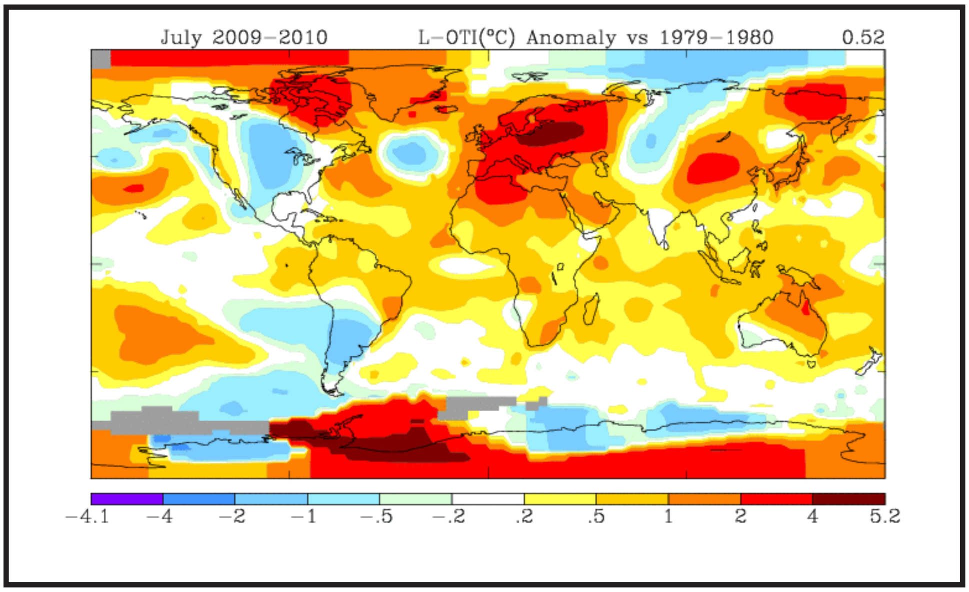
      Greatest increase:

      Least increase:

d. Which global regions are expected to experience the greatest decrease in soil moisture between 2007 and 2080? Which regions are expected to experience the least decrease (or an increase)?

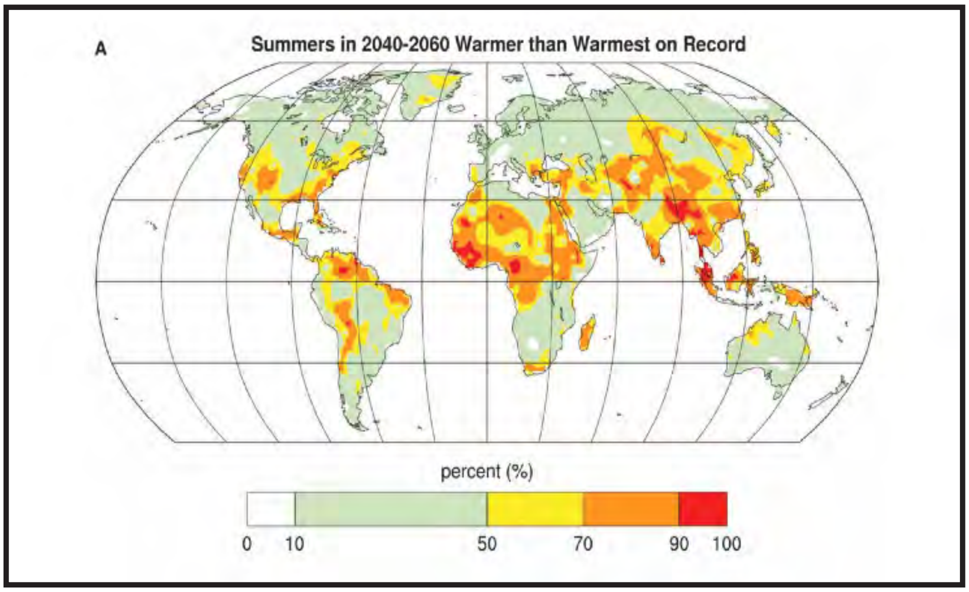
Greatest decrease:

Least decrease:

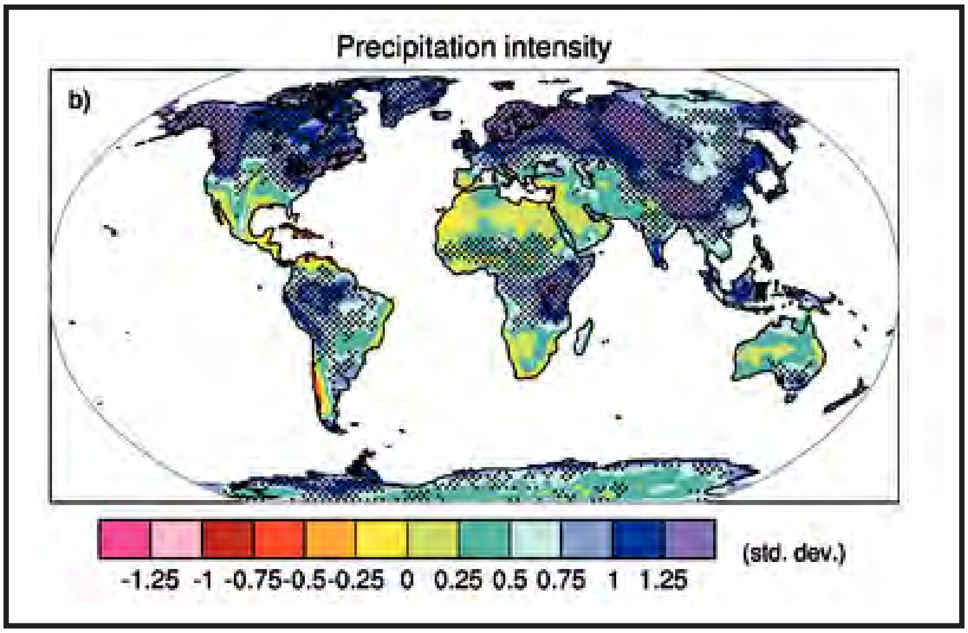


Source: NASA Goddard Institute for Space Studies Surface Temperature Analysis Maps. http://data.giss.nasa.gov/gistemp/maps/. Accessed 01 May 2012.

Note: The map shows net changes in mean July temperature between the periods 1979–1980 and 2009–2010. Darker reds indicate a greater increase in temperature; blues indicate a decrease in temperature.

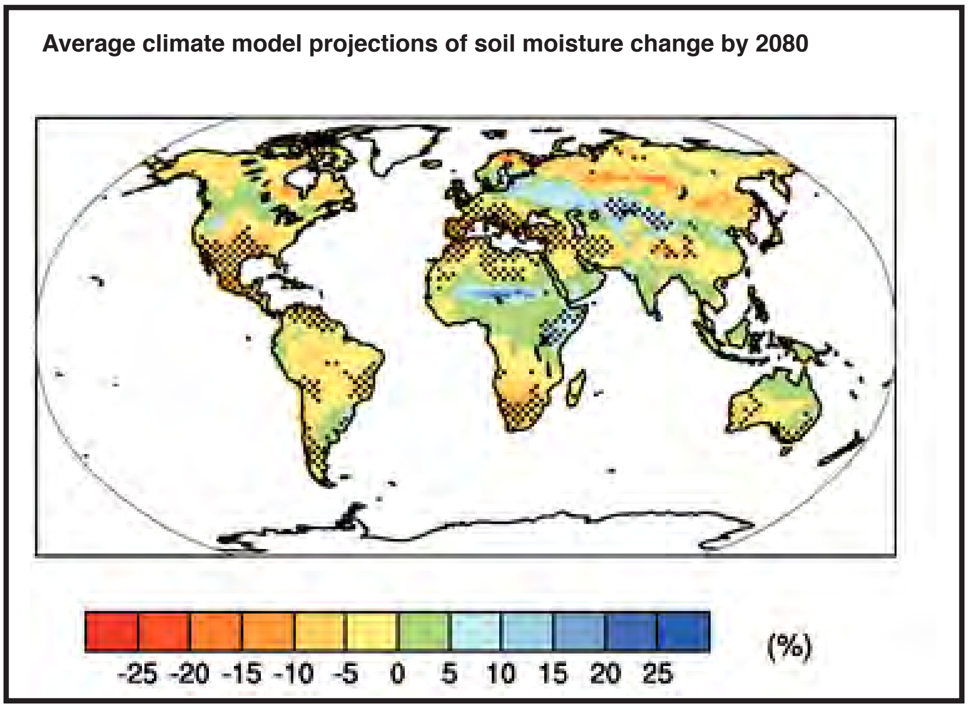


Source: Naylor, R.L. and Battisti, D. 2009. Historical Warnings of Future Food Insecurity with Unprecedented Heat. Science 323(5911): 240–244.



Source: IPCC Assessment Report 4 (2007), Physical Science Basis, Figure 10.18

Notes: The scale in this figure (std. dev.) indicates the projected change between the mean precipitation intensity in years 1980–1999 and the mean precipitation intensity in years 2080–2099; black dots indicate areas where a majority of climate models agree that the projected change is statistically significant.



Source: IPCC Assessment Report 4 (2007), Physical Science Basis, Figure 10.12

Note: Black dots in this figure indicate areas where a majority of climate models agree that the projected change is statistically significant.

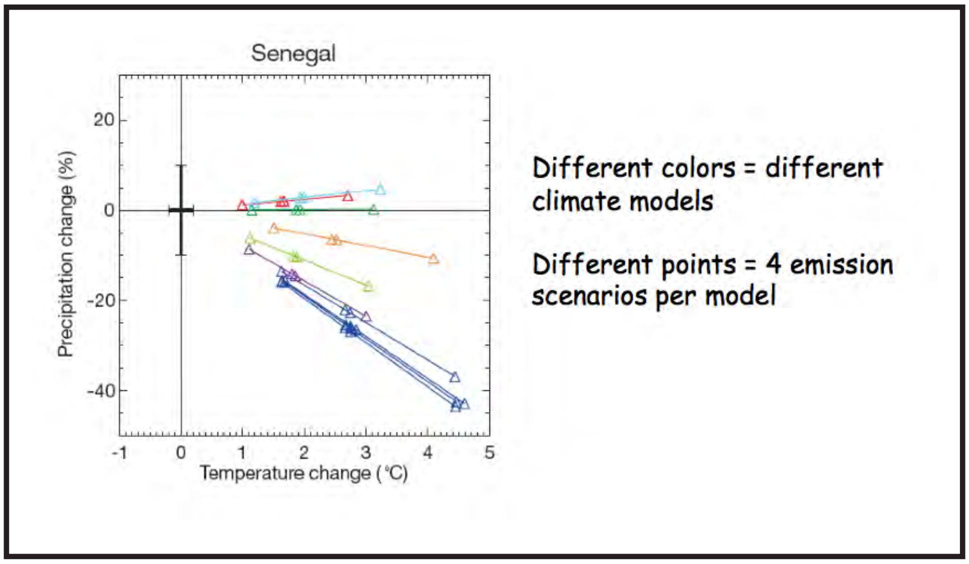
What we don’t know about future climate change

Despite confidence in the claims above, scientists remain uncertain regarding many finer details of future climate change. In general, climate change predictions are more reliable at large spatial scales (changes over a continent, region, or the entire globe as opposed to a country or city) and temporal scales (changes over decades as opposed to months and years). In particular, it is more difficult to predict:

1. Changes in local rainfall patterns

   While we might know that the atmospheric “bucket” of rain will increase in size, it is harder to predict exactly where rainfall will increase and decrease. A modest decrease in African rainfall, for example, might mean very small decreases spread over the entire continent, or very large decreases in some areas balanced by increases in others.

   The chart below, which shows rainfall forecasts for the African nation of Senegal, illustrates the range of variation in local rainfall projections. While most climate models predict that rainfall will decrease, the magnitude of the decrease (less than 4–5°C of warming) ranges from 10% to 40%, and a few models predict a small increase



Source: Lobell, David. “Climate Change and Agricultural Adaptation.” Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century. Stanford: Center on Food Security and the Environment. Presentation delivered at Stanford University, December 8, 2011.

2. The rate of temperature increase

   On average, today’s climate models project a temperature increase of about 0.3–0.4°C until 2050. The actual prediction of any particular model, however, might be as high as 0.5°C per decade or as low as 0.2°C per decade, depending on the exact representation of physical climate processes within the model. Although a difference of 0.3°C per decade might seem inconsequential, only a very small shift in average global temperature is necessary to cause dramatic changes in the frequency of local extreme events and in the overall functioning of the global climate system.

3. Changes in year-to-year temperature and rainfall variability

   We have already discussed some examples of climate change manifested as increased climate variability: for example, spatial and temporal variability in water access will increase as dry areas become drier and rainfall occurs in much heavier, but less frequent, events. However, given the coarse scale of today's climate models, variability at finer scales is much harder to predict. For example, if average temperatures increase by 0.3°C during the next decade, how will that increase manifest on a day-to-day basis? Should we expect a uniform increase in temperature across all days and seasons, or should we expect very hot days in summer, balanced by colder spells in winter?

   Most climate models suggest the latter; with increasing average temperature, we should expect increasing variability in both temperature and rainfall. However, projections are far from unanimous. Some models show no measurable increase in climate variability over the next century; some even show a modest decrease.

Why do these changes—both certain and uncertain—matter for agriculture? Even if you have never tried to grow your own food or flowers, you probably know that climate is a key factor in plant growth. Plants are sensitive to both extreme heat and extreme cold. They need a steady supply of water; too little and their roots will become parched, but too much, and they will drown. Heat waves, low soil moisture, and heavy rainfall events will restrict the growth of most crops, and may be fatal to some.

In the remainder of this lesson, you will study the effects of climate change on agriculture and food security in greater detail. You will learn which regions and crops will suffer most under the projected changes in global climate—and which may benefit, at least in the short term—and why. You will also weigh the pros and cons of different strategies to support agriculture and protect and food security in the face of a changing climate.

Viewing Guide, Lobell Lecture Clip, Impacts of Climate on Agriculture

famine—the United Nations formally defines a famine as a hunger crisis that meets three extreme criteria: at least 20 percent of households in an area face extreme food shortages with a limited ability to cope; acute malnutrition rates exceed 30 percent; and the death rate exceeds two persons per day per 10,000 persons

In the summer of 2011, a prolonged drought in the Horn of Africa contributed to widespread hunger in Somalia, with tens of thousands of deaths and many more refugees. For the first time since 1992, the United Nations issued a formal declaration of famine in Somalia on July 20, 2011. Meanwhile, across the world, and at the other end of the development spectrum, the Corn Belt of the United States experienced a massive heat wave in July 2011, during the critical flowering phase of maize. Subsequent yields were well below trend line, helping to prop up an already high world price of maize.

In the eyes of some, these two recent stories exemplify the threats that climate change poses to food security: conditions for crop growth in subsistence areas deteriorate from bad to worse, leading to massive food insecurity and migration; conditions in high production areas deteriorate by enough to raise world prices, harming food importers; and efforts to cope with the changes are not enough to avoid the suffering of millions.

The two examples also raise many questions that characterize the difficulty of adapting to climate change: Were the droughts in Eastern Africa related to global warming or simply natural variability? Is climate really the main culprit, or is focusing on political institutions and overall development the best long-run approach for coping with climate disasters? And will the private sector in the United States rapidly develop new heat tolerant seeds, or are major investments in public research and development needed to avoid global impacts of climate change?

- Lobell, David. "Climate Change and Agricultural Adaptation." Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century. Stanford: Center on Food Security and the Environment. December 8, 2011.

In the short term, lower local crop productivity means lower ______________ and ___________.

In the long term, lower crop productivity may impede local _____________________.

Consider the following quote from the lecture:

"When we say we want to know what's going to happen in Senegal and Kenya, we don't really only want to know what happens in Senegal and Kenya…we want to know what's happening in the global markets."

Why are global climate effects increasingly relevant for local food security?

Changes in crop productivity are one way that climate change affects food security. Lobell lists several other food security threats that might increase with climate change, such as:

How will higher atmospheric CO_2 concentrations affect crop productivity?

How does heavy rain affect crop productivity?

How does warming affect crop productivity in high latitudes? In low latitudes?

What are the five main reasons that temperature matters for agriculture?

The effect of temperature on the crop depends on ____________________, __________________, and ___________________________.

Rank the following crops in order of their heat tolerance (low to high): maize, wheat, sorghum, barley, irrigated rice.

Why are fertilized crops more sensitive to changes in climate?

Which global regions and/or crop systems will experience the heaviest crop productivity losses from climate change?

True or false: Increased crop productivity due to higher atmospheric CO_2 is likely to offset the negative effects of temperature for at least the next century.

True or false: Higher global temperatures have not yet begun to affect crop yields, although the effects are likely to be apparent in the next decade.

Viewing Guide, Lobell Lecture Clip, Climate Change Adaptation Strategies

In the boxes below, define and give an example of each type of climate change adaptation strategy. Your examples may relate to agriculture and food security, or to other industries and issues affected by climate change (for example: human health, species diversity, conflict, migration, etc.)

Autonomous adaptation	Planned adaptation
Soft adaptation	**Hard adaptation**
Resilience-building adaptation	**Impact-avoiding adaptation**

Give an example of

1. A planned, soft, resilience-improving adaptation strategy:

2. An autonomous, hard, impact-avoiding adaptation strategy:

Climate Policy Essay Assignment

In this lesson, you have learned about global climate change and its expected effects on global food production. You have also reviewed different approaches to supporting agriculture, and protecting food security, in the context of future changes in Earth's climate system. For this assignment, you will synthesize your knowledge of both science and policy in a brief opinion essay, in which you argue for a particular approach to climate change adaptation. Respond to the following prompt:

In order to minimize future threats to global food security, should policymakers focus on adaptation strategies that avoid specific climate impacts or on strategies that build general resilience?

Your essay should be 500–600 words in length. You should mention specific adaptation strategies that illustrate your understanding of the climate impacts and of the distinction between resilience-improvement and impact-avoidance. Your essay should also discuss the pros and cons of autonomous vs. planned and hard vs. soft adaptation strategies.

Consider the following questions:

1. Are resilience-improving or impact-avoiding strategies more:
    a. Politically feasible (i.e., widely supported by leaders and citizens of both developing and developed countries)
    b. Economically feasible (i.e., less expensive, or easier to obtain funding for)
    c. Technically or physically feasible (i.e., easy to implement given current knowledge, technology, human and natural resources, etc.)

    Explain.
2. How well do impact-avoidance strategies improve general resilience? How well do resilience-improvement strategies prepare communities for specific climate threats?
3. Based on your work in this lesson and unit, what major factors (including, but not limited to, climate change) do you feel pose the greatest immediate threat to global food security, and why?
4. What factors do you think will pose the greatest threat to global food security in the future, and why?
5. How well do impact-avoiding and resilience-improving adaptation strategies, respectively, respond to specific threats present and future threats?
6. Is it more important to address immediate threats, to prepare for anticipated threats, or to maintain flexibility in case unanticipated threats appear? Why?
7. In general, how well do impact-avoiding and resilience-improving adaptation strategies, respectively, address immediate, anticipated, and unanticipated threats to food security?

There is no "right" answer; both approaches to adaptations have pros and cons. Your essay will be evaluated based on your ability to adopt and logically defend a clear position; be sure to consider and discuss opposing perspectives, and to draw on lesson and unit materials to support your points. As this is an opinion piece, you may also express your own thoughts and draw on personal experiences, but these should not form the core of your argument. You may access other sources, such as research and news articles on climate change, if you wish. Be sure to cite any sources outside the unit materials.

The passage below, excerpted from a paper by Stanford professor David Lobell, elaborates on the pros and cons of resilience improvement and impact avoidance. Read the passage carefully. You may also draw on this material as you craft your essay.

Recommendations for adapting agriculture to climate change are typically of two types, which appear to stem from two different views on the meaning of adaptation. On the one hand are what I will call the ***"welfare improvers," who define adaptation as anything that restores welfare to what it would have been without climate change****. For example, the International Food Policy Research Institute (IFPRI) suggests an additional $7 billion USD per year to help agriculture adapt to climate change (Nelson et al. 2009), with much of this going to building roads or general agricultural research. Similarly, in an effort to measure the costs of adapting to climate extremes, the World Bank poses the question (World Bank 2010):*

> *"As climate change increases potential vulnerability to extreme weather events, how many additional young women would have to be educated to neutralize this increased vulnerability? And how much would it cost?"*

Thus, ***the goal is to compensate for welfare losses, not to avoid the impacts of the extremes…***

On the other hand are what I will term the ***"impact avoiders," who view adaptation as an action that adjusts explicitly to the change in climate****. For example, the IPCC defines adaptation as: "Adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."*

Both views of adaptation have some merit, but both also have some weaknesses. The welfare improvers are correct to point out that adjusting to the new climate, for instance by improving drought tolerance of seeds, may not be the most cost-effective way to improve productivity or food security. Better to build up overall welfare levels, they would say, which will improve resilience for any shock, including those related to climate. At the same time, the welfare improver perspective can be a convenient stance for those who do not understand the specifics of the climate risks, or who are simply advocating for more resources for their existing activities.

The impact avoiders can reasonably say that there are unique activities associated with adjusting to climate that are not covered by traditional development activities. At the same time, a narrow focus on avoiding impacts could arguably result in worse food security outcomes than a broader strategy.

- Lobell, David. "Climate Change and Agricultural Adaptation." Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century. Stanford: Center on Food Security and the Environment. December 8, 2011.

Quiz

1. List three changes in climate that scientists are relatively certain will occur in the next century.

2. List three aspects of future climate change that scientists cannot predict with certainty.

3. Explain how and why a drought in the United States' Corn Belt might affect food security in rural Africa.

4. Compare and contrast the impact of each of the following on crop productivity. Be sure to mention the direction of the impact (positive or negative), the magnitude (big or small), and whether the impact will vary across regions or crops.
   a. An increase in atmospheric CO2 concentrations

   b. An increase in global average temperature

   c. An increase in precipitation intensity

5. List three reasons that temperature matters for agriculture (i.e., three ways that temperature can affect crop health).

6. To reduce crop yield sensitivity to climate change, we should focus on:
   a. Increasing the share of global cropland that is irrigated
   b. Increasing the share of global cropland that is fertilized
   Explain your answer.

7. In which global region(s) does climate change pose the greatest threat to:
   a. Agricultural productivity
   b. Food security

   Explain your answers, including your reasons (if applicable) for listing different regions in (a) and (b).

Climate Change News Analysis Assignment

For this assignment, you will need to find a news article about the effects of climate change on agriculture. You may choose to analyze an article about climate impacts in a particular region or for a particular crop, or one that deals with the topic of climate and agriculture more broadly. Be sure that your article is from a trusted professional news source (i.e., not a blog or other personal Web site).

Read your article carefully, and then compose a review of the article that answers the following questions:

- When was the article written, and by whom?
- What crops and regions does the article focus on (if the article focus is global, say so)?
- What aspects of climate change does the article discuss (warming, drying, etc.)?
- What is the central message of the article (stated in no more than two sentences)?
- How does the article relate to what you have learned in this lesson?
  - o Does the article offer an example of a general trend that you have studied, e.g., increasing temperatures or precipitation intensity?
  - o Does the article describe an exception to a general trend that you have studied? If so, explain.
  - o Does the article mention climate trends or effects other than those that you have studied? If so, describe.
  - o Does the article omit any information that you have studied that might be relevant to this region or crop? If so, describe.
  - o Does the article suggest any specific adaptation strategies? Categorize these strategies as hard or soft, planned or autonomous, and resilience-improving or impact-avoiding.
- What is your overall impression of the article?
  - o Does the article reflect a good understanding of climate science and climate change forecasts?
  - o Do you think that the article provides a good overview of climate impacts for the region or crop in question?
  - o Does the author refer to science and policy experts to support his or her points?
  - o Is the author's style engaging, well organized, and easy to follow?

Your review should take the form of a well-organized essay, about 500 words in length. Use vocabulary from the lesson as appropriate, and be sure to check your spelling and grammar. Print your review and your article to bring to class.

Answer Key to Handout 1 (Introduction to Climate Change Science)

Study the maps below, and answer the following questions:

Note: The answers below suggest general trends that students should note. Answers will vary, however, as there are exceptions to these general trends and many smaller trends that are also noteworthy.

After reviewing these answers, emphasize the following generalizations:

- *Net warming is more rapid at high latitudes (poles).*
- *Increase in extreme heat is more notable at the equator, because temperature variability in equatorial regions has historically been quite low.*
- *Existing deserts become drier, while wet areas receive more heavy rainfall.*

a. Which global regions experienced the greatest net increase in July temperatures between 1980 and 2010? Which regions have experienced the least increase (or the greatest decrease)?

Greatest increase: high latitudes (North and South poles); land surfaces

Least increase: oceans, mid latitudes (North and South America, northern Asia)

b. Which global regions are expected to experience the greatest percentage increase in extreme summer temperatures between 2009 and 2050? Which regions are expected to experience the least increase (or the greatest decrease)?

Greatest increase: tropics and mid latitudes

Least increase: high latitudes, poles

c. Which global regions are expected to experience the greatest increase in precipitation intensity between 1980 and 2080? Which regions are expected to experience the least increase (or the greatest decrease)?

Greatest increase: High latitudes and the equator (many areas that already experience heavy rainfall, i.e. tropical rainforests)

Least increase: arid mid latitudes (southern United States, Central America, northern and southern Africa, southeastern South America, Australia)

d. Which global regions are expected to experience the greatest decrease in soil moisture between 2007 and 2080? Which regions are expected to experience the least decrease (or an increase)?

Greatest decrease: mid latitude arid regions: Northern and southern African deserts, southern Europe, southern U.S., Central America, Australia, southeast South America

Least decrease: low latitudes of Africa; mid latitudes of Europe, Asia, and North America

Answer Key to Handout 2 (Viewing Guide, Lobell Lecture Clip, Impacts of Climate on Agriculture)

In the short term, lower local crop productivity means lower ______________ and ___________.
Food availability, incomes, or similar

In the long term, lower crop productivity may impede local _____________________.

Economic development; infrastructure improvements; average income growth

Consider the following quote from the lecture:

"When we say we want to know what's going to happen in Senegal and Kenya, we don't really only want to know what happens in Senegal and Kenya … we want to know what's happening in the global markets."

Why are global climate effects increasingly relevant for local food security?

Countries are increasingly connected through global markets; e.g., Africa imports a majority of its rice and wheat. Note: This means that global effects are very important, which is good, because we understand then better!

Changes in crop productivity are one way that climate change affects food security. Lobell lists two other food security threats that might increase with climate change:

Disease prevalence (human diseases, e.g., malaria)

Conflict (e.g., flooding leads to migration, which leads to conflict over land and water, etc.)

How will higher atmospheric CO2 concentrations affect crop productivity?

Positively: "Crops are in the business of taking CO2 from the air and doing the magic of photosynthesis, and making sugars … you add more CO2 to the air, it can do it a little bit faster"

Not evenly beneficial: Temperate crops (C3) benefit more, low-latitude crops (C4) benefit less)

How does heavy rain affect crop productivity?
Negatively, because there is less moisture penetrating the soil (runoff); flooding kills plants

How does warming affect crop productivity in high latitudes? In low latitudes?
Can be positive or negative in high latitudes; almost always negative in low latitudes

What are the five main reasons that temperature matters for agriculture?
Crop growth (photosynthesis and respiration processes) are sensitive to temperature; at high temperature, photosynthesis goes down and respiration goes up, so that the crop is using more energy and making less.

Crop development (transition through life stages) occurs faster at high temperature; faster development means less time spent on each stage, with a possible sacrifice of growth quality.

Water stress: Because warm air holds more water, the pressure gradient between air and plant increases at higher temperature, and water is "sucked" out of plants at a higher rate.

Direct temperature damage can occur at both very high and very low temperatures.

Biotic stresses (pests, disease, etc.) may increase at higher temperatures.

The effect of temperature on the crop depends on ___________________, _________________, and _________________________.

Crop type; nutrient status (fertilized vs. nutrient stressed); irrigation

Rank the following crops in order of their heat tolerance (low to high): maize, wheat, sorghum, barley, irrigated rice

Wheat/barley, maize, rice/sorghum

Why are fertilized crops more sensitive to changes in climate?

They have few other constraints; note that this counteracts, in a sense, the effects of irrigation in developed crop systems.

Which global regions and/or crop systems will experience the heaviest crop productivity losses from climate change?

Tropics (warming will be greatest)—primarily Africa and Asia

High-input rain-fed systems (U.S. Corn Belt)

Systems growing crops with high temperature sensitivity (wheat)

True or false: Increased crop productivity due to higher atmospheric CO2 is likely to offset the negative effects of temperature for at least the next century.
False

True or false: Higher global temperatures have not yet begun to affect crop yields, although the effects are likely to be apparent in the next decade.
False

Answer Key to Handout 3 (Viewing Guide, Lobell Lecture Clip, Climate Change Adaptation Strategies)

In the boxes below, define and give an example of each type of climate change adaptation strategy. Your examples may relate to agriculture and food security, or to other industries and issues affected by climate change (for example: human health, species diversity, conflict, migration, etc.).

Autonomous adaptation	Planned adaptation
Adaptation that private citizens (farmers, businesses, etc.) will undertake to cope with climate change on their own, with minimal external organization. Autonomous adaptation occurs at the scale of a single farm, household, or business. Examples include improving water storage systems at the farm level and constructing new buildings away from flood zones. These strategies will be more effective if they are supported by organized incentive programs (e.g., the government distributes free water storage containers or offers a tax deduction for companies that build outside flood zones) but such incentives are not necessarily essential to the success of the strategy.	Adaptation that must be planned and organized by a central authority, such as a national government. Planned adaptation strategies include those that individuals are not usually able to undertake alone. Examples include expanding road networks, implementing large-scale health or welfare support programs, building dams and dikes for flood control, maintaining national and international seed banks and agricultural research programs, etc.
Soft adaptation	**Hard adaptation**
Adaptation that involves changes in resource management and human behavior, without construction of new infrastructure. Examples include relocating populations outside flood zones, improving early-warning systems for extreme weather events, planting more drought-resistant crops, etc.	Adaptation strategies that involve construction of new physical infrastructure. Examples include transportation and communication infrastructure, wells and irrigation channels, flood control systems, etc.
Resilience-building adaptation	**Impact-avoiding adaptation**
Adaptation strategies that improve a community's overall ability to respond to any threat, including but not limited to climate change. Examples include education and health-care programs, improvements to transportation and communication infrastructure, research that improves agricultural yields across all crops and regions, etc.	Adaptation strategies that improve a community's specific ability to cope with climate-related threats. Examples include flood control and water storage infrastructure, improved weather forecasting and early-warning systems, and crop research targeted to develop drought tolerance or flood resistance.

Give an example of:

1. A planned, soft, resilience-improving adaptation strategy

   Answers will vary. Possibilities include: providing better public education or social welfare programs; conducting general agricultural research targeted to improving yields in a range of regions, crops, and climatic conditions.

2. An autonomous, hard, impact-avoiding adaptation strategy

   Answers will vary. Possibilities include: building new buildings away from coastal areas or flood zones; drilling wells, constructing irrigation channels, or improving water storage capacity.

Answer Key to Handout 5 (Quiz)

1. List three changes in climate that scientists are relatively certain will occur in the next century

   Global temperatures will increase; precipitation intensity will increase; dry regions will become drier

2. List three aspects of future climate change that scientists cannot predict with certainty

   Changes in local rainfall patterns; the exact rate of temperature increase; changes in climate and weather variability

3. Explain how and why a drought in the United States' Corn Belt might affect food security in rural Africa.

   Answers will vary slightly. Students should recognize that, due to increasing globalization of food production and distribution systems, any local change in productivity could have ripple effects around the world. Specifically, students should recall that the U.S. is a major producer of corn, and a major supplier of exports and food aid to Africa; therefore, a drop in U.S. corn production poses a threat to food security in Africa.

   Excellent responses will specifically mention that U.S. corn production is primarily rain-fed; thus, a drought will have a significantly negative impact on output and yields.

4. Describe the impact of each of the following on crop productivity. Be sure to mention the direction of the impact (positive or negative), the magnitude (big or small), and whether the impact will vary across regions or crops.

   a. An increase in atmospheric CO2 concentrations

      Moderate positive impact on productivity; greater for temperate C3 crops, less for tropical C4 crops

   b. An increase in global average temperature

      Large negative impact in low latitudes; possible moderate positive impact at high latitudes; larger negative impact for less heat-tolerant crops (wheat) vs. more heat-tolerant (maize, rice, sorghum)

   c. An increase in precipitation intensity

      Almost uniformly negative impact, due to negative consequences of flooding, runoff, and soil erosion

5. Describe three reasons that temperature matters for agriculture (i.e., three ways that temperature can affect crop health)

   Answers will vary slightly. Lobell describes five major reasons:

   - *Crop growth (photosynthesis and respiration) processes are sensitive to temperature; at high temperature, photosynthesis goes down and respiration goes up, so that the crop is using more energy and making less.*
   - *Crop development (transition through life stages) occurs faster at high temperature; faster development means less time spent on each stage, with a possible sacrifice of growth quality.*
   - *Water stress: Because warm air holds more water, the pressure gradient between air and plant increases at higher temperature, and water is "sucked" out of plants at a higher rate.*

- *Direct temperature damage can occur at both very high and very low temperatures.*
- *Biotic stresses (pests, disease, etc.) may increase at higher temperatures.*

6. To reduce crop yield sensitivity to climate change, we should focus on:

   a. Increasing the share of global cropland that is irrigated

   b. Increasing the share of global cropland that is fertilized

   Explain your answer.

   The correct answer is (a): increasing the share of global cropland that is irrigated. Irrigation directly addresses a consequence of climate change (reduced water availability), while fertilization addresses soil nutrient deficiencies and imbalances. Yields in fertilized fields will actually be more sensitive, percentagewise, to climate changes, since they are not limited by nutrient availability.

   Note that fertilization is still a good idea; irrigation is simply the priority. Applying fertilizer to irrigated cropland will further improve yields, increasing the overall resilience of the global food production system.

7. In which global region(s) does climate change pose the greatest threat to:

   a. Agricultural productivity

   b. Food security

   Explain your answers, including your reasons (if applicable) for listing different regions in (a) and (b).

   Answers will vary somewhat. In (a), students should recall the regions that Lobell mentions: the African and Asian tropics, where warming and drying will be most pronounced; high-input rain-fed systems such as the U.S. Corn Belt, where water availability is they primary limiting factor for crop production; and regions growing heat-sensitive crops such as wheat (including, for example, top wheat producers such as China, Northern Europe, Canada, and Australia). In (b), students should note that the actual food security consequences are likely to be greater in developing regions of the African and Asian tropics, where many people rely on subsistence agriculture. Developed countries will be better able to import and distribute food to compensate for domestic productivity losses.

Variability and Change

Farmers have always dealt with unexpected year-to-year changes in temperature and water availability. Some growing seasons have always been hot and dry, others cooler and wetter. What, then, makes climate change different? Why might climate change have unusual or especially severe consequences, requiring new, targeted adaptation strategies? The following paragraphs, excerpted from a paper by Stanford University professor David Lobell, explain how and why scientists distinguish between **climate variability** and **climate change**.

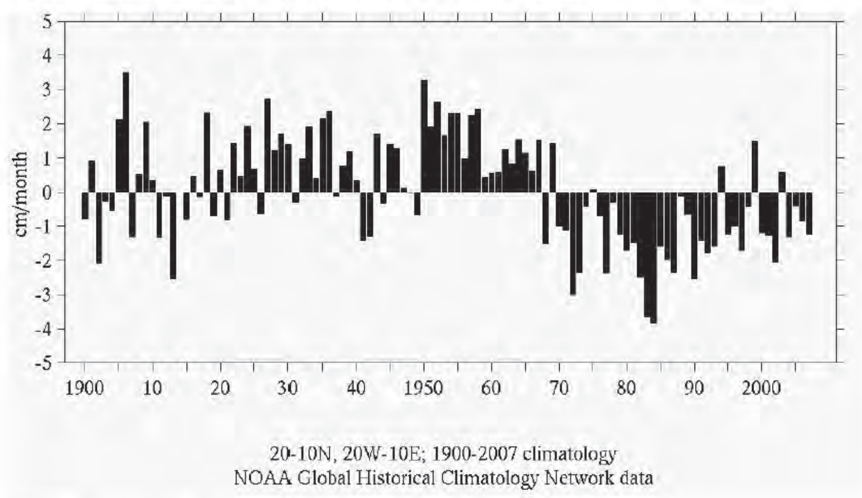
Climate change versus climate variability

Excerpt from Lobell, David. "Climate Change and Agricultural Adaptation." Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century. Stanford: Center on Food Security and the Environment. December 8, 2011.

Weather has always been a concern to farmers and herders. Every year brings a different combination of temperature, rainfall, cloudiness, and various other factors that affect agriculture. This inter-annual variability results from the simple fact that the Earth is a spinning sphere of land and (mostly) water, with sunlight unevenly distributed across the world. As energy and water moves around the Earth's atmosphere and oceans, many patterns of natural variability emerge. A well-known example is the El Niño Southern Oscillation, driven by changes in the tropical Pacific that then propagate throughout the world.

Just as no two years are the same, decades can also differ significantly because of natural variability of the climate system. For example, Figure 1 shows rainfall in the Sahel region over the 20th century. Some decades are very wet, such as the 1920s or 1950s, and some are very dry, such as the 1970s and 1980s. Although some of this variability is due to changes in external factors, such as aerosol concentrations, most of the variability is simply the result of internal dynamics in the climate system (Giannini et al. 2003).

Figure 1. JJASO-mean Sahel precipitation anomalies 1900-2007



Source: JISAO 2011. A century of growing season rainfall in the Sahel region.

Climate change is distinct from climate variability. The former term describes changes that occur because of human activities, especially the emissions of greenhouse gases, whereas climate variability refers to changes that result from internal dynamics of the climate system, independent of any external forcing. At first glance, the distinction between climate change and variability may seem arbitrary and unhelpful. After all, no one is exposed to only climate variability or only climate change, but to the combination of the two. If the weather is changing in a farmer's field, why does the cause of this change matter when deciding how to respond?

However, the distinction is very important for anyone seeking to understand adaptation to climate change, for two main reasons. First, the processes underlying climate change are very different than those behind natural variability. In the former case, accumulation of greenhouse gases in the atmosphere traps outgoing heat, leading to an increase in the overall energy of the climate system. Natural variability occurs because of internal dynamics in the climate system, which are fed by gradients in solar radiation and ocean circulation. As a result of different underlying processes, one should expect different weather variables to be affected.

For example, internal natural variability leads to large fluctuations in rainfall from year to year in many locations, as illustrated for the Sahel in Figure 1. But natural variability in temperature is quite low throughout the tropics, with the warmest and coolest years often differing by less than 2°C. In contrast, global warming has its strongest effect on temperatures, with often much smaller effects on rainfall than natural variability.

- *Lobell, David. "Climate Change and Agricultural Adaptation." Stanford Symposium Series on Global Food Policy and Food Security in the 21st Century. Stanford: Center on Food Security and the Environment. December 8, 2011.*

Lobell Lecture Summary

Adapting Agriculture to Meet the Challenge of Climate Change

Most effective policies are those that recognize the strengths and weaknesses of climate science, says Stanford professor.

When it comes to climate change and its impacts on agriculture, we may know less than we think.

But according to Dr. David Lobell, an Assistant Professor in Stanford's Department of Environmental and Earth Systems Science, acknowledging the gaps in our understanding could help us to more effectively prepare the world's food system for a warmer future.

Lobell, who has built an impressive career around the study of climate change and its implications for global food security, addressed the topic of agricultural adaptation during a two-hour symposium held on the Stanford campus in early December. His presentation summarized the strengths and weaknesses of climate models in the context of global agriculture, and suggested broad strategies for preparing agriculture for climate change's inevitable impacts.

Lobell began his talk by reaffirming some common beliefs. The Earth as a whole is unquestionably warming, he said. Precipitation intensity is increasing in high-rainfall areas, and the world's driest regions are becoming drier.

"Think about the hottest day we currently experience in a 20-year period," Lobell told listeners. "By mid-century, we'll be seeing that hottest day every year, as opposed to every 20 years." During the same period, soil moisture content in many of the world's major agricultural areas will decrease by as much as 10 to 15 percent, while annual precipitation at the equator and high latitudes will increase by several inches per year.

At the global scale, Lobell said, climate change will have a net negative impact on existing agricultural systems. The world's rainfed farms will become increasingly vulnerable to heat and water stress. Growing ranges and seasons for heat-intolerant crops, such as wheat and sorghum, will contract. Although the high latitudes may see some gains from warmer temperatures and CO2 fertilization of certain crops, low-latitude regions—including South Asia and much of Africa—will suffer disproportionate yield losses as temperatures rise.

However, Lobell said that impacts aimed at local and national scales, as opposed to broad regions or the world as a whole, are much more difficult to predict. A moderate change in average rainfall across a continent could translate to drastic increases or decreases in individual countries. For example, while climate models suggest that Africa's annual rainfall will change by less than 10 percent over the next 50 years, model projections show rainfall in the nation of Sengal changing by anywhere from five to 40 percent over the same period.

Additionally, Lobell said, forecasts of increasing climate variability are frequently overstated. "The number one misperception I hear is that climate change is going to mean more variability," he noted. In fact, model projections of year-to-year variability in temperature and precipitation cover a wide range. Some models do show large increases in variability over the next century—but others show a slight decrease.

Because we understand climate impacts best at the long-term and global scales, Lobell said, global responses that address long-term trends are the most likely to serve our future needs. He cautioned against approaches that prepare farmers for short-term variability, such as sudden floods or droughts, but fail to acknowledging the effects of steadily rising average temperatures. He also stressed the value of globally coordinated efforts, particularly those aimed at developing better heat and drought-tolerant crop varieties, to supplement local infrastructure projects.

"We're in a world where local resilience depends on global systems," Lobell noted. He said that the interconnectedness of modern global food markets makes global trends, and global responses, increasingly relevant for local food security.

At both local and global levels, an effective response to climate change will require robust social institutions. Dr. Fatima Denton, Program Leader for Climate Change Adaptation in Africa for the Consultative Group on International Agricultural research, stressed this point in her comments on Lobell's presentation. "Climate change has really unmasked our governance challenges and the weaknesses in our institutions," Denton said. "This is not just about biophysical processes … it's about the development pathways that we choose."

Lobell agreed. Climate change, he said, presents "an important opportunity for transformation." He encouraged present and future leaders to think critically about all aspects of the relevant science and policy. "Be skeptical of what you hear," he advised, "and educate yourself about what we do and don't know."

Lesson Seven

Suggested Concluding Activities

Organizing Questions

- How do activities and conditions at each stage of the food supply chain (production, distribution, and utilization) affect food security?
- How are the key features of international development projects summarized in a grant proposal, and how can this format be applied to projects that address food security?
- How do United States government policies affect global food security, and what changes could the U.S. make to improve food security?
- What is the World Food Prize, and what are some accomplishments that have been—or may be—considered worthy of recognition by this award?

Introduction

The following activities are intended to help students synthesize and apply the material in this unit. Students are asked to trace the life cycle of a common food item, compose a grant proposal for a food security–related project, recommend government policies to promote global food security, and to research past recipients of the World Food Prize. All four activities include both a research and writing component and a discussion or presentation component.

Teachers may use one or more of these activities as they see fit. Teachers have the option of assigning the concluding activity at the beginning of the unit, allowing students to work on the activity on their own schedule as they gain relevant knowledge through the other unit lessons, or of assigning the concluding activity after the class has completed the other unit lessons.

Objectives

In this lesson, students will

- review key concepts from previous lessons in this unit;
- appreciate a wide variety of efforts by groups and individuals to improve food security over the past half-century;
- synthesize their knowledge to evaluate food security issues and propose potential solutions to food security problems; and
- work in various formats, including grant proposals, policy memos, and oral presentations.

Materials

- Handout 1, *Food Research Project*
- Handout 2, *Mock Grant Proposal*
- Handout 3, *Policy Memo*
- Handout 4, *World Food Prize*

Time

The longer activities (Food Research Project and Mock Grant Proposal Project) require about one week of class and homework time, while the shorter activities (Policy Memo and World Food Prize) require about two or three days.

Teacher Preparation and Procedures

Preparation and Procedures for Activity One: Food Research Project

1. Make the appropriate number of copies of Handout 1 (one per student).
2. Distribute one copy of Handout 1 to each student. Give students a few minutes to review the instructions, and then discuss the requirements and answer any questions.
3. Allow four or five days for students to work on the project.
4. Give each student about three minutes to deliver his or her oral presentation to the class. Invite questions after each student finishes speaking. For a class of 30 students, allow two class periods for the oral presentations.
5. Evaluate student work based on:
    a. Research effort (number of questions answered, quality and number of sources cited, etc);
    b. Writing quality (organization, style, grammar, and spelling in the final paper); and
    c. Presentation quality (content, organization, and professionalism).

Preparation and Procedures for Activity Two: Mock Grant Proposal

1. Make the appropriate number of copies of Handout 2 (one per student).
2. Distribute one copy of Handout 2 to each student. Give students a few minutes to review the instructions, and then discuss the requirements and answer any questions.
3. Allow three or four days for students to work on the project.
4. Give each student about five minutes to deliver his or her project pitch to the class. Invite questions after each student finishes speaking, and then ask the class to vote on whether the project should be funded. For a class of 30 students, allow three class periods for the oral presentations.
5. Evaluate student work based on:
    a. Completeness of the grant proposal (all sections included and all questions addressed within each section);
    b. Quality of the project idea (is the idea creative and yet still practical?);
    c. Writing quality (organization, style, grammar, and spelling in the grant proposal); and
    d. Presentation quality (content, organization, and professionalism).

Preparation and Procedures for Activity Three: Policy Memo

1. Make the appropriate number of copies of Handout 3 (one per student).
2. Distribute one copy of Handout 3 to each student. Give students a few minutes to review the instructions, and then discuss the requirements and answer any questions.
3. Allow one or two days for students to work on the project.
4. Divide the class into groups of three or four students. Ask students to share their policy recommendations with their group. Each group should discuss all the proposals represented, and choose one recommendation to present to the class.
5. Give each group one minute to present their chosen recommendation to the entire class. Write a brief description of each recommendation on a whiteboard or blackboard. When all groups have presented, ask the class to vote for a single recommendation that they would support.
6. Evaluate student work based on:
   a. Completeness of the memo (does the student consider all of the questions listed?);
   b. Quality of the policy recommendation (is the recommendation creative and yet still practical?);
   c. Writing quality (organization, style, grammar, and spelling in the policy memo); and
   d. Contributions to the final group and class discussion.

Preparation and Procedures for Activity Four: World Food Prize

1. Make the appropriate number of copies of Handout 4 (one per student).
2. Distribute one copy of Handout 4 to each student. Give students a few minutes to review the instructions, and then discuss the requirements and answer any questions.
3. Allow one or two days for students to work on the project.
4. Give each student about two minutes to deliver his or her oral presentation to the class. Invite questions after each student finishes speaking.
5. Evaluate student work based on:
   a. Research effort (depth and breadth of the student's understanding of the Laureate's life, work, and contributions);
   b. Quality of the future Prize description (are the student's ideas creative, practical, and clearly linked to the past Laureate's work?);
   c. Writing quality (organization, style, grammar, and spelling in the press release); and
   d. Presentation quality (content, organization, and professionalism).

Food Research Project

Choose a food item that you eat frequently—this could be a basic fresh food, such as a fruit or vegetable, or a processed item such as bread, lunch meat, or yogurt. If you select a processed item, you may choose to focus on one major ingredient (e.g., if you selected bread, you may choose to focus your research on wheat).

Write a well-organized 1,000- to 1,500-word paper that responds to the following question:

How do production, distribution, and utilization of (your food item) affect global food security?

In order to answer this question, you will need to research the production, distribution, and utilization of your food item. Consider the questions below in your research; you may not be able to answer every question, but do your best to answer several questions in each category. As you compose your paper, think about how your food item might affect poverty, health, and other factors relevant to food security at each stage of its "life cycle." Be sure to cite the sources that you use in your research.

When you have finished your written report, prepare a two or three minute oral presentation on the food security impact of your food item's production, distribution, and utilization. Incorporate at least one visual aid in your presentation, such as an image of your food item or a graphic depicting the production or distribution process.

Production

- Where is this item grown or produced? List major producing countries or regions.
- How much of this item is grown or produced each year?
- Describe the production process:
    - o What is the timeline of production, e.g., when are crops planted and harvested, or how long must animals mature before slaughter?
    - o What inputs (water, fertilizer, animal feed, etc.) are required?
    - o Is the item grown or produced mostly by a few large farms/businesses, or are there many small producers in the market?
    - o What is the balance of human vs. machine labor in the production process?
- Has the efficiency of production (with respect to time, land inputs, or other resources) increased significantly at any point in the past 30–50 years? Are there any ongoing research projects focused on improving production efficiency? If so, describe their strategies and success to date.
- How might climate change affect production of this item during the next century?

Distribution

- How much did you pay for this item?
- How much of the price that you paid do you think that the producer of the item received? Try to find information on the producer price or "farm gate price" of your item.
- Which countries or regions export this item? Which countries or regions import this item?

Utilization

- What is the health value of this item? Is it high in protein or healthy fats? Does it contain key micronutrients?
- Is this item consumed throughout the world? Is it a cultural staple or delicacy consumed only in certain countries or regions? Is it a "luxury" product consumed only in wealthy countries and households?
- Are other uses (e.g., biofuel production) competing with human food consumption for this item?

Mock Grant Proposal

Imagine that you are the director of a nonprofit organization that focuses on food security issues. You are planning to apply for a large grant, which will fund a particular project that you believe will have a significant impact on food security in one country or community. In order to receive the grant, you will need to write a proposal describing your project plan and the reasons that your work deserves funding. Your finished proposal should be about 1,500 words in length and should include the following sections:

1. Background
   a. Describe the general problem that your project addresses.
      i. What is "food insecurity"?
      ii. Give evidence to support the position that food insecurity is a significant global issue.
      iii. Describe several barriers to achieving global food security.
   b. Describe the specific problem that your project addresses.
      i. Which of the barriers listed above will your project address? Explain why you chose to address this specific issue.
      ii. Choose a specific country in which to locate your project. Explain why you chose this country.

2. Project Description
   a. What action will you carry out?
   b. Who will benefit?
      i. Estimate how many people will be affected by your project.
      ii. If you will focus on a particular community or demographic within your country, describe your focus and the rationale behind it.
   c. For how long will the project operate?

3. Resources
   a. Human resources
      i. How many people will you need to carry out the project?
      ii. What roles will you need to fill? Will the project require any specialized skills?
      iii. Where will you find the people you need? Will you collaborate with any other organizations? Will you need to recruit volunteers?
   b. Fiscal resources
      i. Approximately how much do you think this project will cost?
      ii. Break down the cost of the project into approximate categories. How much do you expect to spend on activities directly related to the project (e.g., purchasing fertilizer to distribute to poor farmers) versus on administrative tasks (e.g., recruiting volunteers, paying your own salary, etc.)?
      iii. How much money are you requesting from this grant? Will you have other funding sources? If so, describe them.

c. Other resources: Will you need special equipment, services, or other resources not listed above? If so, describe them.

4. Evaluation and Exit Strategy
   a. How will you know whether your project is a success? Try to list both quantitative (numeric) and qualitative measures.
   b. How will you obtain accurate information on the success metrics listed above (e.g., how will you monitor a family's food consumption or income for increases over time)?
   c. How frequently will you check and report on your progress?
   d. What will you do if you are not meeting your goals? Describe specific obstacles that you might encounter and the steps that you would take to overcome them. Do you have a "Plan B"—relocating the project, decreasing the scale, etc.—to make good use of your funding if you encounter insurmountable obstacles?
   e. How will you know when the project is complete? How will you ensure that the project's effects are sustained after your organization's active involvement comes to an end?

When you have completed your written proposal, prepare a five-minute PowerPoint presentation describing and defending your project. Your presentation should address each of the sections included in your proposal. Include at least three images or graphics—pictures of your focus country or community, tables and graphs illustrating your funding breakdown and progress metrics, etc. This presentation is your project "pitch," which you will present to your classmates and teacher to convince them that your project deserves funding. Be creative and persuasive!

Suggested resource (for sample grant proposals and description of the grant process): The Bill and Melinda Gates Foundation, *Grants Overview*, http://www.gatesfoundation.org/grantseeker/Pages/default.aspx

Policy Memo

Imagine that you are an adviser to the President of the United States, and you have been assigned the task of recommending a single action that the U.S. should take to improve global food security. Write a 500- to 600-word memo that explains the action you recommend and your reasons for recommending it. Consider the following questions:

- What particular challenge(s) to global food security does this action address (inadequate crop yields, high food prices, poverty, climate change, etc)?
- What are some other challenges to global food security, and why are they less pressing than the challenge(s) addressed by your recommended action?
- What practical steps are you suggesting that the U.S. take? Who will be involved, and how will the efforts be funded?
- Convince your reader that the steps you suggest, if properly executed, will effectively overcome the targeted challenge(s).
    - o Think about other steps that might accomplish the same goal, and explain why your strategy is superior.
    - o Identify and refute possible objections to your strategy. Think about ethical, cultural, and political objections as well as practical (economic, logistical) concerns.

You will discuss your recommendations with a small group of your classmates. Be prepared to defend your strategy.

World Food Prize

The World Food Prize is awarded annually to an individual who has "advanced human development by improving the quality, quantity or availability of food in the world" (www.worldfoodprize.org). Since 1987, the prize has recognized a wide range of achievements, from advances in crop breeding and agricultural technology to groundbreaking political and economic reforms.

Visit the World Food Prize website, and read through the biographies of several past prize laureates. Choose one laureate to focus on for this project, and complete the following tasks:

- Learn as much as you can about the life, work, and contributions made by your chosen laureate. At a minimum, you should carefully study the biography and other materials on the World Food Prize website; you may wish to consult other online sources, as well. Prepare a one-minute presentation on your laureate's contributions.
- Think about how additional progress in the direction(s) pursued by your laureate could further improve global food security. For example, if your laureate helped to improve yields of a certain staple crop, additional work might be needed to improve the same crop's drought resistance in anticipation of future changes in climate. Write a short (250-word) press release describing a fictional future World Food Prize Laureate who has contributed to the additional work that you suggest. Describe how his or her accomplishments build on those of past laureates, and how his or her work affects global food security.

You will have about two minutes to present your laureate's biography and a summary of your fictional press release for your classmates. After your presentation, your teacher will collect your written press release, along with any presentation notes.

Appendices

Glossary

2008 food price crisis: refers to food price spikes during the year 2008. For example, between July 2007 and July 2008, the international price of corn jumped from $7.80 to $13.80 per bushel—an increase of more than 75 percent. Similar price spikes occurred in other staple grains, such as wheat and rice.

Agrarian: rural, agricultural

Anemia: a condition associated with deficient or poorly functioning red blood cells, resulting in symptoms such as fatigue, pale skin, and general weakness. Anemia is often caused by inadequate dietary intake of iron or Vitamin B12.

Asset (productive asset): a physical item, or a characteristic of a person or group, that has monetary value or income-generating potential

Average cost: a producer's cost-per-unit including all fixed costs and all variable costs: (fixed costs + variable costs)/(number of units produced)

Biodiesel: a substitute for diesel fuel produced from biological raw materials

Biofuel feedstock: the biological raw material used to produce a biofuel. For example, corn is a common ethanol feedstock.

Biofuel: a fuel produced from biological raw materials

Chronic poverty: persistent poverty, enduring for years, decades, or generations; contrast with transitory poverty

Comparative advantage: an economic principle stating that countries (or businesses, individuals, etc.) maximize benefits by producing only the goods and services that they can produce most efficiently relative to all other goods and services, and trading those goods and services with others to meet their needs

Consumer price: the price paid for a good or service by its consumer

Correlated: two phenomena (such as changes in the prices of two commodities) are correlated if they usually accompany or parallel one another. Note that this does not imply that one phenomenon causes the other to occur; i.e., correlation does not imply causation.

Daily consumption expenditure: the amount of money that an individual or household spends per day on basic goods and services

Disposable income: income available to be spent or saved at the discretion of its earner (after deduction of taxes, mandatory charges, etc.)

Eutrophication: oxygen deprivation occurring in lakes, rivers, and oceans as a result of overfertilization (often associated with fertilizer runoff from agricultural operations)

Exports: domestically produced goods moved out of a country (via commercial sale or donation to other countries)

Externality: an "external" cost or benefit of a product that is not reflected in the market (i.e. sale or purchase) price of the product

Fallow: uncultivated; to "fallow" a piece of land means to forgo planting the land with crops for one or more seasons

Famine (U.N. definition): at least 20 percent of households in an area face extreme food shortages with a limited ability to cope; acute malnutrition rates exceed 30 percent; and the death rate exceeds two persons per day per 10,000 persons

Fertilizer: any substance that contains a sufficient quantity of the essential plant nutrients to act as an effective soil restorative and an aid in plant growth

First generation biofuels: biofuels produced from food crops

Fixed costs: costs for inputs that are purchased once, regardless of production quantity, such as land and machinery

Food and Agriculture Organization of the United Nations (FAO): a U.N. specialized agency with the mandate to "raise levels of nutrition, improve agricultural productivity, better the lives of rural populations and contribute to the growth of the world economy"

Food price dynamics: a general term for the patterns of movement in food prices (e.g., increases and decreases, e.g.) and the forces that drive them

Food Security: when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (World Food Summit, 1996).

Fossil fuels: fuels that form deep in the earth, through geologic process acting on plant and animal remains

Gini Coefficient: a quantitative metric of national income inequality, with 0 indicating perfect equality (all citizens of the country earn equal income) and 1 (or 100) indicating perfect inequality (one citizen earns 100 percent of the country's income)

Greenhouse gases: atmospheric gases that absorb outgoing radiation emitted from the Earth's surface and reemit part of it back toward the surface, producing insulating and heating effects

Gross Domestic Product (GDP): the value of all final goods and services produced within a country in a given year

Gross National Income (GNI): the total income earned by a country's citizens in a given year, including income earned by citizens working abroad in other countries

Haber-Bosch process: a technique for synthesizing inorganic ammonia, which is a common ingredient in nitrogen-based inorganic fertilizers

Hunger: food deprivation; an uncomfortable or painful sensation caused by insufficient food energy consumption

Imports: Externally produced (foreign) goods moved into a country (via commercial sale or donation)

Industry: a specific group of businesses or activities within a sector; e.g., the agricultural industry, the clothing industry, etc.

Inorganic fertilizer: a chemically manufactured substitute for natural fertilizers. Inorganic fertilizers usually contain much higher nutrient concentrations than naturally occurring fertilizers.

Intergovernmental Panel on Climate Change: the leading international body for the assessment of climate change, formed in 1990 by the United National Environment Programme and the World Meteorological Society

International Food Policy Research Institute (IFPRI): one of 15 agricultural research centers supported by the Consultative Group on International Agricultural Research (CGIAR), charged with the specific mission of "providing policy solutions that reduce poverty and end hunger and malnutrition"

Landrace: a wild plant that has adapted to specific local conditions through natural processes

Leguminous plants: plants in the family *Leguminosae*. Common examples include peas, beans (including soybeans), lentils, peanuts, alfalfa, and clover.

Macroeconomics: the branch of economics that focuses on the behavior and welfare of a national or regional economy as a whole

Macronutrients: dietary components that the body requires in large quantities each day. The three major macronutrients are carbohydrates, protein, and fat.

Malnutrition: a health condition resulting from deficiencies, excesses or imbalances in the consumption of macronutrients and/or micronutrients

Mandate (biofuel): a law or policy that requires production and/or use of a specific quantity or mixture of biofuels, usually on a national and annual basis. For example, the United States' Renewable Fuel Standard mandates that the U.S. consume 15 billion gallons of corn-based ethanol each year starting in 2015

Microeconomics: the branch of economics that focuses on the behavior and welfare of individual economic actors (households, companies, consumers, etc.)

Micronutrients: nutrients that the body requires in smaller daily quantities. Micronutrients include vitamins, such as vitamins A, C, D, and K, and minerals such as calcium and iron.

Mineral nutrients: inorganic (non carbon-based) nutrients, obtained by plants through soil absorption rather than through photosynthesis

Minimum dietary energy requirement: the minimum level of daily calorie consumption deemed necessary to "conduct sedentary or light activities" (the FAO maintains country-by-country estimates)

Monetization (of food aid): the sale of donated food in a (usually in the aid-receiving, i.e. developing and/or food insecure, country) to generate funds for other development programs

Net food buyer: someone for whom the total value of the food they consume exceeds the total value of the food they produce

Net food seller: someone for whom the total value of the food they produce exceeds the total value of the food they consume

Organic (natural) fertilizer: naturally occurring substances that contain high concentrations of essential plant nutrients, such as livestock manure or powdered mineral rocks

Per capita GDP/GNI (GDP/GNI per capita): the average output produced/income earned per person in a given country in a given year, i.e., total GDP/GNI divided by the country's population

Poverty gap: the difference between an average poor individual's or household's daily consumption expenditure, and the poverty line consumption expenditure, expressed as a percentage—the average "distance below" the poverty line

Poverty: deprivation related to economic consumption and food security, health, education, rights, voice, security, dignity and decent work (adapted from the Organisation for Economic Co-operation and Development (OECD) definition of "poverty")

Poverty headcount ratio: the percentage of a population (e.g., global or national) whose daily consumption expenditure falls below the poverty line

Poverty line: a cutoff level of daily consumption expenditure, below which an individual or household is classified as "poor"

Precipitation intensity: a measure of the average "heaviness" of rainfall events: total rainfall divided by total number of rainy days

Price ceiling: one example of a direct price control—an upper limit (usually imposed by a government) on the price of a good or service

Price floor: one example of a direct price control—a lower limit (usually imposed by a government) on the price of a good or service

Primary sector: economic activities that involve extraction of primary, unprocessed natural resources for direct sale or consumption

Producer price: the price received for a good or service at the initial sale by its producer

Profit: a producer's net earnings, - i.e., the difference between total revenue (income from sales) and total costs of production

Quota: a mandated maximum or minimum amount; for example, an import quota usually specifies the maximum quantity of a particular good that a country will import

Retailer: one who sells directly to consumers

Seasonal food insecurity: a cyclical pattern of inadequate availability and access to food, associated with seasonal fluctuations in the climate, cropping patterns, work opportunities, and disease

Second-generation biofuels: biofuels produced from inedible agricultural products such as shrubs,grasses, and fast-growing trees

Secondary (industrial/manufacturing) sector: economic activities that involve processing the outputs of the primary sectors into higher-value products

Sector: a broad category of economic activity

Self-reliance (food): a country is food self-reliant if domestic firms, individuals, and the government can purchase enough food in commercial markets to meet domestic consumption demands (compensating for any shortfall in domestic food production, i.e., any deficit in food self-sufficiency)

Self-sufficiency (food): a country is food self-sufficient if domestic farmers produce enough food to meet domestic consumption demands

Stochastic poverty: poverty that results from chance events (unemployment, weather or health shocks, etc.) in the presence of adequate asset wealth

Structural poverty: Poverty that results from a fundamental lack of productive assets

Stunting: low height for age; a symptom of undernourishment

Subjacent poverty: a level of poverty defined by IFPRI: per person consumption expenditure between $0.75 and $1 per day

Subsidy: a direct or indirect payment, usually granted by a government, intended to promote economic activities deemed to be beneficial to society

Subsistence farming: farming solely to produce food for household consumption, with no surplus for market sale

Symposium: a conference, meeting, or interactive presentation on a particular subject; a collection of essays or papers on a particular subject by a number of contributors

Tariff: a tax levied on traded goods

Tertiary sector: economic activities that use a range of outputs from the primary and secondary sectors to offer services or produce "intangible" goods such as education and hospitality

The Green Revolution: a series of breakthroughs in crop breeding and agricultural technology that occurred during the 1960s and 1970s. The Green Revolution led to dramatic increases in staple crop yields, particularly in Asia and Latin America.

Third-generation biofuels: biofuels produced from certain species of algae

Transitory poverty: poverty that occurs in short spells (a few months or less).

Ultra poverty: A state of especially deep poverty; the "poorest of the poor." May also refer to various quantitative definitions, e.g., less than $0.50 per day, food consumption below 80 percent of energy requirements, etc.

Undernourishment: a state in which an individual consumes insufficient daily calories to "conduct sedentary or light activities" (FAO 2008)

Variable costs: costs for inputs purchased in quantities that vary according to the total production quantity, such as labor, seed, and fertilizer

Wasting: low weight for age; a symptom of undernourishment

Wholesale price: the price received for a good or service by a wholesaler (usually, the price paid by the retailer)

Wholesaler: a middleman between consumer and producer. Usually, a wholesaler buys goods in large quantities from producers, and sells them to retailers, who make the final sale to consumers

World Food Programme (WFP): the United Nations' frontline food aid agency

Yield (crop): the amount of crop harvest output per some given quantity of input—usually land—e.g., metric tons of output per hectares of area harvested

Zoonotic disease: a disease that can be transmitted from animals to humans

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