

# Unit 7

## Agriculture

### Background

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#### Introduction

Will the Earth have enough agricultural resources to provide food for an ever-expanding human population? One key factor in determining our agricultural future is how food demand will change in relation to increasing population, higher incomes, and individual preferences. Another key factor will be competition of marginal land resources. Will the land be used for agriculture or urbanization? In light of global climate change, we must take into consideration that today's agricultural patterns may change in response to evolving precipitation, temperature, and weather patterns. Scientists and farmers are beginning to address the overuse and negative impacts of fertilizer and pesticide in ways that may lead to greater ecological sustainability. Economists are investigating the ability of farmers to maintain the sustainability of their commercial farm production. What will agriculture be like for future generations?

#### Essential Questions

What are the most productive forms of agriculture and how are we manipulating them to increase food production?

What are the benefits and drawbacks of fertilizer and pesticide use?

How can farmers change their agricultural practices for more sustainable food production and economic outcomes?

#### Content

Unit 7 focuses on the underlying principles of plant growth, Earth's resources, fertilizers, pesticides, and food production. The video for this unit describes agricultural practices related to rice production and sustainable economics for modern farmers. In the video you will learn how scientists such as Peter Kenmore from the United Nations Food and Agricultural Organization have been working with farmers to decrease the use of fertilizers and pesticides in rice production. We see the engagement of rice farmers in participatory and community-based scientific research that then informs their agricultural practices. This approach raises questions about the nature of science: who does it and when is it considered valid. The second part of the video describes how the perspective of today's farmers is changing to a conservation ethic and preservation of soil resources for future generations. Professor Pamela Matson studies the interactions of nitrogen in soil, water, and air resources in order to determine how to maintain ecosystems and farmers' standard of living.

# Background

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## Learning Goals

During this session you will have an opportunity to build understandings of the following.

- a. Knowledge
  - i. Agricultural production has kept pace with population increases primarily as a result of increased inputs.
  - ii. Earth has limited land resources for agriculture based on temperature, topography, climate, soil quality, and available technologies.
  - iii. The primary limiting factor for food production is the amount of water and nitrogen available for photosynthesis.
  - iv. Increased yields are a result of increased inputs.
  - v. The use of fertilizers and pesticides has ecological consequences.
  - vi. Recent technological innovations have influenced agricultural strategies.
- b. Skills
  - i. Science is a process in which farmers and agricultural communities can participate.
  - ii. Science is an experimental process that includes verification of past studies.
  - iii. Science is a collaborative process.
- c. Dispositions
  - i. Sustainability is essential to agricultural production for future generations.

## Key Concepts

Photosynthesis	Irrigation	Radiometers
Increasing Yields	Fertilizers	Credit unions
Pests and disease	Pesticides	Photosynthesis
Livestock	Integrated pest management	Stomata
Biotechnology Agriculture and energy	Experimental design	Stomata
Sustainable agriculture	Peer review	Transpiration
Global climate change	Phytoplankton	Eutrophication
Harvest index	Green revolution	

**FACILITATOR:** These concepts correspond roughly to the sections of the unit. There are a number of other concepts that could be included. It is best to start with the author's major ideas and then ask for input from the study group for other concepts they would include.

# Background

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## Misconceptions about Agriculture

Agriculture is a declining industry and is less important because of its lower relative contribution to GNP and employment.

Agriculture is important because everybody eats food and lower income groups spend a large portion of their income on food. More nutritious food is a benefit to everyone.

Food production problems have been solved. Food prices are lower and there are surpluses.

In fact, new production technologies have raised new questions and created new ecological and economic issues. With more urbanization, increasing population, and rising income levels, world food demand is expected to increase significantly.

Agriculture can only be destructive/harmful to ecosystems and natural resources.

New approaches to agriculture, including integrated pest management and more sophisticated understanding of production techniques, can have positive impacts on natural systems.

## Related Misconceptions about Ecology

Insects are harmful and eliminating them will benefit humans.

Many insects eat plants and can affect plant production. The elimination of some insect pests has disrupted natural predator-prey systems and resulted in decreased food production.

The addition of more nutrients automatically results in increased food production.

The careful and systematic use of fertilizers can result in increased production without increasing fertilizer application.

## Getting Ready (45 minutes)

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### Activity One: Assessing Prior Knowledge, Questions, and Related Experiences

**FACILITATOR:** Each participant is given three index cards. On the first card, participants should indicate something they know about agriculture and agricultural procedures, such as the use of fertilizers and pesticides for control of insects. On the second card, they should write one question they have about either agriculture and food production. And on the third card, they should describe an experience they have had with agricultural concepts. Examples of comments and/or questions might be:

Agricultural practices in the world today are highly efficient.

Is the trade-off between food production and pesticide use worth it?

I met a person who argued that genetically modified foods are dangerous.

# Getting Ready

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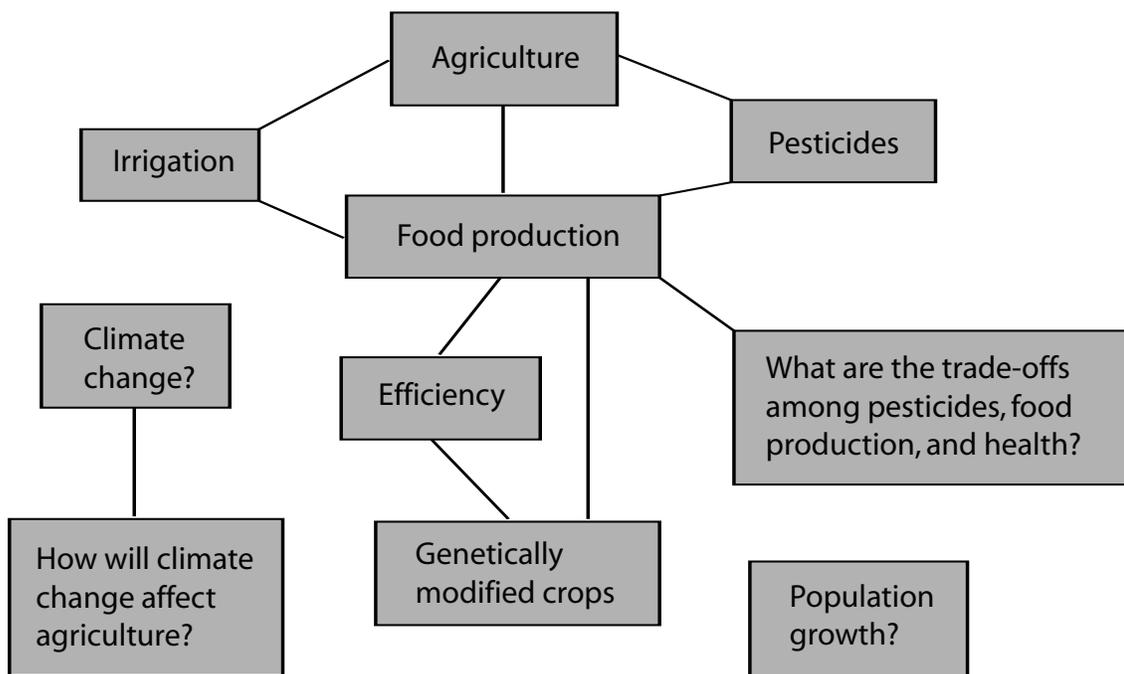


Figure 7.1 An example of a study groups' idea collection, with major subjects identified and the addition of the major focus ideas of the video. This activity links individual pre-existing knowledge with that of other members of the group and the unit content.

## Activity Two: Current Events & Editorial Cartoons

Participants will share an article that they have found that relates to the week's topic. All members of the group will share their headlines for the articles. The leader should ask a few people to summarize their articles and ask for comments from others with related articles. As the group discusses the articles, a participant should record key concepts and make a list. (Participants may choose to bring in a cartoon or an editorial related to the week's topic instead of an article.)

## Activity Three: A Sustainable Agricultural Land-Use Scenario

In 1983, the World Commission on the Environment and Development, known as the Brundtland Commission, was established to assess the world's environmental problems and propose a global agenda for addressing these issues. The Commission identified a variety of environmental issues, such as living conditions, natural resources, population pressures, international trade, education, and health, and created a definition of sustainable development. According to the Brundtland Commission, sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

This activity allows participants the opportunity to work through a potential sustainability scenario regarding the use of agricultural land and the application of chemical fertilizers, pesticides, and insecticides.

**FACILITATOR:** This activity will work best with at least three participants. If there are more, then groups of four work well.

# Getting Ready

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## Materials

A large number of small objects of two different colors, such as small garden decorating stones, marbles, or candies.

Paper bags—one per group.

## Setup

1. Divide the participants into groups of four.
2. Give each group a paper bag that contains 16 stones (or marbles) of one color. Each stone represents a hectare (2.5 acres) of usable agricultural land.
3. Give each group a handful of stones of a different color. These represent the fertilizers, pesticides, and insecticides.

## Procedure

Participants draw one or more stones representing agricultural land from the paper bag. Each participant has to draw at least one stone in order to maintain an economically profitable level on his or her farm.

If participants do not draw a stone, then they lose their farm and are out.

Participants may take as many stones from the bag as they choose.

At the end of each round described below, the stones in the bag are counted, and an equal number of stones is added to the bag.

## Activity

1. Round 1 and 2: First generation farmers. For each stone removed by a participant from the paper bag, one stone representing a fertilizer, pesticide, etc., is added to the paper bag immediately.
2. Round 3 and 4: Second generation farmers. For each stone a participant removes, three fertilizer stones are added to the bag immediately.
3. Round 5 and 6: Third generation farmers. For each stone removed from the bag, three fertilizer stones are added to the bag immediately.

## Discussion

How did the action of the first generation farmers affect the third generation farmers?

During what round did the system collapse so that only polluted agricultural land remained? Explain what happened.

Were farmers able to sustain the agricultural resource? If so, how did they accomplish this?

Relate this scenario to the functional definition of sustainability presented by the Brundtland Commission.

How does this activity model the agricultural experiment shown in the video or described in the online text, especially as it relates to the future needs of generations of farmers?

# Video (45 minutes)

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## Activity Four: Watch the Video

As you watch the video, think about the following focus questions.

1. Are there advantages to growing rice in marginal environments?
2. What are the contradictory results from using pesticides to control insects in rice paddies?
3. Why is it important for farmers to conduct field experiments?
4. How does the study of nitrogen cycling illustrate a systems approach to understudying this issue?
5. How did the radiometer, the Green Seeker, illustrate how a technological breakthrough can add to an understanding to this fertilizer-environment issue?
6. What are the problems presented by the sugar cane borer and how has this been controlled?

## Activity Five: Discuss the Video

Discuss the following questions about the video.

1. How will we feed the growing population and at what costs to the environment?
2. How do we meet the needs of people and decrease the use of pesticides and fertilizers?
3. How does natural selection play a role in the insect control dilemma?
4. Discuss the experimental design in the field for controlling insects.
7. Discuss the continuum of observation-discovery-new knowledge for managing the fields and the overall findings of this process.
8. Discuss the social and financial influence of credit unions on the fertilizer-environment issue.

**FACILITATOR:** Refer back to the misconception section and Activity One: Assessing Prior Knowledge. Has the video contributed to the participants' new understanding of concepts? Are there any changes the participants would make about the arrangement of their cards from Activity One?

# Going Further (60 minutes)

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## Activity Six: Bioaccumulation

### Objective

Participants will develop an understanding of why some toxicants (such as pesticides) bioaccumulate. Most chemicals that bioaccumulate dissolve in lipids and therefore are not excreted but stay in body tissue.

# Going Further

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## Materials

Oil	Fishing pole	16 test tubes
Red dye	Red marker	1-liter beaker
5 100 ml beakers	Pipettes	Fish consumption advisories
2 400 ml beakers	Stirring rods	(one per participant)



Figure 7.2 Zooplankton

**FACILITATOR:** The following procedure is designed for a large group of participants. If you are working in a small group, each person could represent one part of the food chain, i.e., one person would represent all the zooplankton, one person all the little fish, etc.

## Procedure

Review the food chain. Put an example on the board.

Explain that some chemicals accumulate in the fat of animals, like the pesticide DDT that was used to kill insects in order to protect crops.

With a group of 23 or 24, have 16 participants represent zooplankton. Give them each a test tube that contains 3 parts water and 1 part oil. These layers represent the fat and water in the organism. You can alter the number of zooplankton if necessary.

4 participants will be little fish. Give them each a 100 ml beaker.

2 participants will be big fish. Give them each a 400 ml beaker.

1 participant will be a fisherman/woman. Give this participant the fishing pole and a 1 liter beaker.

Make a solution using the red dye and oil and indicate to the group that this represents a fat soluble chemical like DDT.

# Going Further

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## Activity

Read the following out loud to the class:

“While the zooplankton were feeding on algae, they digested 4 drops of pesticide. These 4 drops did not kill them or make them sick. However, more than 7 drops would have.”

The zooplanktons should put 4 drops of the “pesticide” in their test tubes and stir them. They will notice the “pesticide” stays in the oil.

Read the following: “Each little fish will eat 4 zooplankton.”

Each little fish should pour the contents of 4 zooplankton into their beaker. Have participants keep track of the amount of “pesticide” in each little fish.

Read the following: “Each big fish will eat 2 little fish.”

Again have participants keep track of the amount of “pesticide” in the fish.

## Discussion

The angler catches and eats two big fish. How many drops of “pesticide” are in the human? It takes 80 drops to kill or make the human sick. How many more infected fish could this human safely eat?

Why are pesticides used in agriculture? Are there other ways to grow crops without using pesticides?

## Activity Seven: Return to Essential Questions

The facilitator should draw the attention of the participants back to the essential questions posed in the Background Section of this unit guide. Discuss how the participants’ ideas may have changed in regard to the questions. Discuss the most logical and complete answers to the questions.

Activity Eight: Discuss Classroom Supplementary Activities

If the participants in the study group are teachers, the facilitator should draw the participants’ attention to supplementary classroom activities located at the end of this guide. Discuss how teachers would implement these activities in their classrooms and how they would relate them to the topics in this unit.

# Between Sessions

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## Next Week’s Topic Overview

Read Unit 8 before the next session. Unit 8 describes how the world’s water supply is allocated between major reserves such as oceans, ice caps, and groundwater. It then looks more closely at how groundwater behaves and how scientists analyze this critical resource. After noting which parts of the world are currently straining their available water supplies, or will do so in the next several decades, the unit text examines how humans are depleting freshwater supplies and the problems posed by salinization, pollution, and water-related diseases.

# Between Sessions

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## Read for Next Session

For the next session be sure to read the Unit 8 Professional Development Guide background section. Consider the essential questions as you read the text. The misconceptions section will give you some insight into what misunderstandings people may have about water resources. Consider discussing the topic with your friends or students and discussing common misconceptions.

## Current Events

Bring in a current event article, cartoon, or editorial related to water resources

# Supplementary Classroom Activity 1

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## Transpiration Lab

Transpiration is the process through which water is lost from a plant by evaporation. Water is taken into a plant through roots and root hairs by osmosis, and it exits the plant through tiny openings on the underside of leaves known as stomata. While the stomata is open to let in carbon dioxide, water is lost. Transpiration is one of the main reasons water moves up the stem of a plant—water moves from a high water potential to a low water potential. In this experiment, four bean plants will be used to test transpiration rates under different environmental conditions. The conditions included a normal room setting (control) and exposure to a fan, heat lamp, and moist environment (plant misted and then covered with a plastic bag). Data will be obtained from each setting to determine if the various conditions affected the rate of water loss from leaves. Have students hypothesize which variable will cause the greatest rate of transpiration.

### Materials

Graduated cylinder	Parafilm	Distilled water
Bean plants	Scalpel	Fan
Heat lamp	Spray bottle	Plastic bag to cover plant
Balance	1 cm x 1 cm graph paper	Scalpel

### Procedure

1. Make a potometer by filling a graduated cylinder with water and covering it securely with parafilm. Poke a small hole in the parafilm. Remove the root from the plant and insert the plant into the parafilm hole so that the end of the stem is well below the water level in the graduated cylinder. Record the initial water level in the potometer. This plant will be your control. Repeat step number one but have a fan blowing on plant #2.
2. Repeat step number one but have a heat lamp on plant #3 .
3. Repeat step number one but mist plant #4 with water and then place a plastic bag over it.
4. Take readings of the potometer every 10 minutes after the initial reading for a total of 30 minutes. Record this data.

# Supplementary Classroom Activity 1

5. At the end of the 30 minutes, select one leaf of average size and trace that leaf on a piece of graph paper. Repeat for each condition.

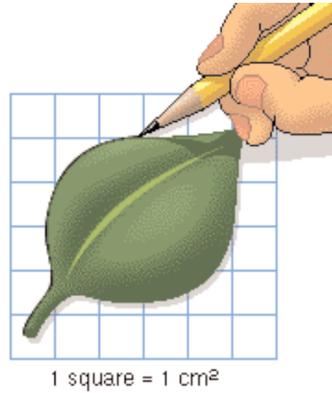


Figure 7.3 Tracing a leaf on graph paper.

6. Using the graph paper, calculate the area of the leaf.
7. Calculate the amount of water loss per square centimeter for each condition.
8. Graph the time versus water loss for each condition.
9. Calculate the rate of water loss for each condition by taking the total amount of water lost divided by 30 minutes.

## Data

Condition	Water level At 0 min.	Water level At 10 min.	Water level At 20 min	Water level At 30 min	Water loss/cm <sup>2</sup>	Rate of Water loss (ml water/min)
Room						
Fan						
Heat Lamp						
Mist						

Conclusion: Which condition had the greatest amount of water loss? Why? How does this affect agriculture?



# Supplementary Classroom Activity 2

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## Conclusion

Discussion: What is an algal bloom?

Where did you see the greatest algal bloom?

Where did you see the lowest dissolved oxygen?

Where do these fertilizers come from? How do they get into a pond?

What are some alternatives to using fertilizers?