**The relationship between agriculture and technology**

**Pillar 5 D. Discover how improved technology in agriculture can help the environment by requiring less input to produce more**

(9th – 12th Grade)

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| **Website**: <http://www.nature.com/nature/journal/v418/n6898/full/nature01014.html>  <http://www.wri.org/publication/creating-sustainable-food-future-interim-findings>  **Hands On**: <http://www.sustainabletable.org/249/sustainable-crop-production> |

 **Fertilizers and the Environment**

**Purpose**

Students will recognize that fertile soil is a limited resource, describe the role fertilizer plays in increasing food productivity, distinguish between organic and commercial fertilizers, describe how excess nutrients are harmful to the environment, and identify different sources of nutrient pollution.

**Materials**

**Activity 1:**

* 1 apple
* 1 knife
* 1 paper plate or cutting board

**Activity 2:**

* Master 5.1, *Newspaper Articles* (1 to project)
* Master 5.2, *Population and Land Use* Graphs (1 per team of 3 students)
* Master 5.3, *Needs of the Future* (1 per team of 3 students)

**Activity 3:**

* Master 5.4, *Thinking about Fertilizers* (1 per team of 3 students\*)
* Master 5.5, *Pros and Cons of Different Fertilizers* (1 per team of 3 students\*)
* Master 5.6, *Nutrient Pollution* (1 per team of 3 students\*)
* Master 5.7, *Nutrient Pollution Discussion Questions* (1 per team of 3 students\*)

\* Half of the teams receive Masters 5.4, *Thinking about Fertilizers* and 5.5, *Pros and Cons of Different Fertilizers,* and the other half receive Masters 5.6, *Nutrient Pollution* and 5.7, *Nutrient Pollution Discussion Questions.*

Essential Files (maps, charts, pictures, or documents)

* [Lesson Handouts: Masters 5.1 - 5.7](https://naitc-api.usu.edu/media/uploads/2015/05/26/Fertilizers_and_the_Environment_Handouts.pdf)

**Vocabulary**

**Algal bloom:** a rapid growth of microscopic algae or cyanobacteria in water, often resulting in a colored scum on the surface

**Fertilizer:** a chemical or natural substance added to soil or land to increase its fertility

**Non point source:** nutrient pollution that results from runoff and enters surface, ground water, and the oceans from widespread and distant activities. Because it comes from a number of different sources, a non point source is much harder to trace and quantify than a point source of nutrient pollution.

**Nutrient:** a substance that provides nourishment essential for growth and the maintenance of life

**Point source:** nutrient pollution that comes from a specific source that can be identified such as a factory or a wastewater treatment plant

**Interest Approach – Engagement**

* Ask your students if they think we have adequate land to grow and produce enough food for a growing population.  *Can every acre of farm land be used to grow food crops or raise animals?*
* Students may picture areas where there is a lot of open space. However, do they realize that not all land is suitable for growing crops?
* Introduce the lesson to students. After completing this lesson, they will be able to:
  + Recognize that farmland is a finite resource;
  + Appreciate that the world’s growing population demands an increase in food productivity;
  + Describe the role fertilizer plays in increasing food productivity;
  + Distinguish between organic and commercial fertilizers;
  + Describe how excess nutrients are harmful to the environment; and
  + Identify different sources of nutrient pollution.

**Procedures**

**Activity 1: The Big Apple**

***Teacher Note:*** This activity uses an apple as a model of Earth. Students discuss the various ways people use land and make predictions about what percentage of Earth’s land is needed to grow our food. After discussing the ways in which land is used (Step 2), you may consider having the students create their own pie charts where they predict the percentages associated with different land uses, especially farming. Later, their predictions can be compared with the actual values revealed by the apple demonstration.

* Explain to the class that this activity is concerned with how we as a society use land. The amount of land on Earth stays the same, so as the world’s population gets larger, it becomes even more important that we make wise decisions about how it is used.
* Explain that land is used for many different reasons. Ask, “What are some of the most important uses for land?” Write students’ responses on the board or an overhead transparency. Students’ responses may include the following:
  + Farming
  + Homes
  + Industries or places where we work
  + Pastures or land for livestock.
  + Parks, sports, and recreation.
  + Wildlife habitat (wetlands, mountain ranges, forests, deserts, beaches, and tundra).

If a student does not mention one of these uses, ask guiding questions to bring it out. A student may point out that some land such as a desert has no use. Of course, any land that is not being used by humans can be considered a habitat for wildlife and provides a variety of other economic services for people. For example, wetlands help remove nutrient pollution from rivers, lakes and estuaries.

* Call attention to the apple and the knife. Explain that the apple represents Earth. Ask, “How much of the total Earth’s surface do you think is devoted to farming?” Students’ responses will vary. Some may remember that about 70 percent of the surface is water.
* Use the knife to cut the apple into 4 equal parts. Set 3 parts aside and hold up 1 part. Explain that the surface of the world is about 70 percent water, so this 1 piece represents that part of the surface that is land. Remind students of the many different uses for this relatively small amount of land.
* Use the knife to cut the 1/4 piece of apple in half 3 more times, each time discarding 1/2. Finally, hold up 1 of the smallest pieces and explain that it represents 1/32 of the surface of Earth or 1/8 the land where we live. This is the amount of land available for farming. Point out that the skin on this small piece of apple represents the tiny layer of topsoil that we depend on to grow food.
* Explain that because we put land to so many different uses, the amount devoted to farming has hardly changed during the past 50 years. Scientists are worried about how we will feed the world’s growing population in the next 50 years.

**Activity 2: Using Land Wisely**

In this activity, students use a world population projection to consider how much additional farmland will be needed to feed humans in the year 2050.

* Remind students that the purpose of diagnosing plant nutrient deficiencies is aimed toward increasing food production for both local and world wide inhabitants.
* Display Master 5.1, *Newspaper Articles* and reveal only the top article. Ask a student volunteer to read the article aloud.
* Explain to students that they will continue in their roles as agricultural experts concerned with increasing crop yields on farms. Ask students to summarize the content of the article.

Try to focus the discussion on the world. Most students in the United States do not have direct experience with severe hunger. Help them understand that in addition to human suffering; hunger can also lead to unstable governments, wars, and threats to national security—including that of the United States. It is in everyone’s best interest to eliminate world hunger.

The article states that population growth contributes to the problem of world hunger. Do not dwell on population control measures. The students are working as agricultural experts and need to focus on how to grow more and better food. The article also mentions availability of freshwater and increasing temperatures as challenges for growing more food. If students do not understand why increasing temperatures cause lower crop yields, explain that it takes more energy for plants (and people) to maintain themselves at higher temperatures. Using humans as an example, you can point out that marathon records are usually set at cooler temperatures.

* Now uncover the bottom article and ask a second volunteer to read it aloud. Ask students to summarize the article.
  1. Students should recognize that there are many factors that influence world hunger and that addressing the problem requires the skills of many different types of professionals including social scientists, climatologists, water management experts, and agricultural experts.
* Divide the class into teams of 3 students . Explain that their first task is to investigate how population growth is expected to affect farming in the future.
* Pass out to each team a copy of Master 5.2, *Population and Land Use Graphs and Master* 5.3, *Needs of the Future*. Briefly review the information with students .
  1. The population graph provides data about the world population from 1950 and projections for the population in the year 2100. The high, medium, and low estimates of the future world population are based on fertility rates (the number of children that people have). Instruct some teams to use the high estimate in their calculations, others the medium estimate, and the rest the low estimate.
  2. The value of 12 percent of land devoted to farming refers to the world as a whole. Obviously, the corresponding figures for different countries vary considerably. This activity is designed to examine the problem of feeding the world and not to explore the situations within individual countries.
* Instruct teams to use the graphs on Master 5.2, *Population and Land Use Graphs* to perform calculations on Master 5.3, *Needs of the Future* about how much farmland will be needed in the year 2050.
  1. Give teams 10 minutes to perform their calculations. The numbers needed to perform the calculations can be estimated from the population graph.
* Ask each team to report the results of their calculations. Write their answers on the board or chart paper.
  1. If any answers are out of the expected range, go through the calculation systematically, identify the mistake, and correct it. Obtain answers using the high, medium, and low population estimates.
* Ask students to summarize the results .
  1. If students do not point this out, emphasize that if crop yields stay the same between now and 2050, then perhaps an extra 1 billion acres of farmland will need to be set aside and cultivated.
* Ask the students to remember the different uses of land that they described in Step 2 of Activity 1, *The Big Apple*.
  1. Point to the list of land uses that students created in Activity 1.
* Ask, “If a billion acres of extra farmland are needed to feed the world’s population, from where should it come? What are you willing to sacrifice?”
  1. Students likely will believe that people must have adequate land for the places where they live and work. They may suggest taking the land from parks or wildlife habitats. Some may suggest that if more people became vegetarians, the extra farmland could come from pastures where livestock graze.
  2. These questions are not intended to settle the issue. Instead, they are intended to prompt a discussion that helps students see the scope of the problem and to consider some of the difficult decisions that may lie ahead.
  3. This step gives you a sense of the students’ awareness of the tradeoffs associated with the reallocation of limited resources.
* Explain that in the next activity, they will consider how farming practices can influence land use and crop yields.

**Activity 3: Fertilizers and the Future**

In this activity, students identify advantages and disadvantages of using organic and commercial fertilizers. They also consider how to minimize nutrient pollution.

Teacher note: The readings about organic and commercial fertilizers are brief. The information is not meant to be comprehensive. Rather, it is designed to challenge students’ critical-thinking skills and provide opportunities for them to construct explanations supported by evidence.

* Remind students that in Activity 2, *Using Land Wisely*, they calculated that approximately 1 billion extra acres of farmland would be needed to feed the world’s population in 2050. Ask, “What were two assumptions made in reaching this conclusion?”
  1. Students’ answers will vary. Some may focus on assumptions associated with the rate of population growth. This is a good answer, but you should guide the discussion to remind students that their calculations assumed that the crop yields from farms would remain constant between now and 2050.
* Ask, “What will be the effect of increasing the amount of food that an acre of farmland can produce?"
  1. Students should realize that if farmland becomes more productive, then fewer acres would be required to meet the world’s food needs.
* Explain that in their roles as agricultural experts , they are going to make recommendations to the Earth Food Bank about how to farm in the future. Explain to students that when considering the proper use of fertilizer, they want to increase crop yields, while at the same time minimizing harm to the environment. Proper application of fertilizer means the following:
  + 1. Fertilizer is added at the right time. Fertilizers should be applied during that part of the plant’s life cycle when the nutrients are needed.
    2. Fertilizer is added at the right place. Fertilizers should be applied in a location where the nutrients can be taken up by the plant’s root system.
    3. Fertilizer is added at the right rate. Fertilizers should be applied at the rate at which the plant can use the nutrients.
* Explain that students need to learn more about fertilizers and their effects on the environment.
  1. Pass out to half of the teams a copy of Master 5.4, *Thinking about Fertilizers* and a copy of Master 5.5, *Pros and Cons of Different Fertilizers*.
  2. Pass out to the other teams a copy of Master 5.6, *Nutrient Pollution* and a copy of Master 5.7, *Nutrient Pollution Discussion Questions*.
  3. Instruct the teams to read the information found on the first handout (either Master 5.4, *Thinking about Fertilizers* or Master 5.6, *Nutrient Pollution*) and to discuss within their teams their understanding. Students should relate the ideas of “right time, right place, and right rate” when considering the use of fertilizers and their impacts on the environment.
  4. Students should use the second handout (either Master 5.5, *Pros and Cons of Different Fertilizers* or Master 5.7, *Nutrient Pollution Discussion Questions*) to record their conclusions.
  5. Students reading about fertilizers should be able to identify 3 or 4 advantages and disadvantages of each type of fertilizer. Students reading about nutrient pollution should be able to describe how excess nutrients can produce algal blooms that use up oxygen in waterways, leading to suffocation of other plants and animals. They should be able to identify wastewater treatment facilities and industrial plants as point sources of nutrient pollution. They should identify urban development, septic systems, the burning of fossil fuels, and agricultural runoff as non point sources of nutrient pollution. Student suggestions for limiting non point sources of nutrient pollution will vary. There is no simple correct answer. Look for logical responses that students can defend using evidence. The idea is to get them thinking about the multiple sources of nutrient pollution and for them to realize that minimizing it will require a complex set of regulations, incentives, and government oversight.
* After the teams have completed their tasks, ask volunteers to read their conclusions.
  1. Make a list of the advantages and disadvantages of each type of fertilizer on the board or on chart paper.
  2. Discuss answers to the questions about nutrient pollution.
* Ask, “Why do you think that some farmers use organic fertilizers and others use commercial fertilizers?”
  1. Student responses will vary. Try to bring out in the discussion that the farmers in the United States have more options than farmers in poorer countries who may have no choice but to use organic fertilizers that they produce for themselves. One consequence is that farmers in poorer countries often obtain lower crop yields as compared with farmers in the United States.
  2. ***Teacher note***: Try to avoid getting bogged down in debating whether or not food that is organically grown is safer or tastes better than food grown using commercial fertilizers. This is not the focus of the lesson. Scientific studies have not been able to find consistent taste, health, or safety differences between foods grown using the two types of fertilizers.
* Conclude the lesson by asking students to hold on to their handouts. Explain that they will refer to them during the next lesson when they will be making recommendations for farming in the future.

**Concept Elaboration and Evaluation**

After conducting these activities, review and summarize the following key concepts:

* Fertile soil that is adequate to grow crops for our food and fiber is a limited natural resource.
* Nutrients are required in the soil to grow healthy plants just like people need nutrients in their diet.
* When nutrients are not available in the soil, they can be added through the use of fertilizer.
* With a growing population, properly using and balancing soil nutrients is very important to the stability of our food supply.
* Farmers use various conservation techniques and technologies to manage their use of fertilizers and diminish negative impacts such as algal bloom or water pollution.

**Essential Links**

* [Lesson Video Clip](https://www.youtube.com/watch?v=COZiR8rlgH8)
* [Nutrients For Life Website](https://www.nutrientsforlife.org/)

**Enriching Activities**

* This lesson is the last in a series of five related lessons. Refer to the following lessons for further depth.
  + [Lesson 1: In Search of Essential Nutrients](http://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=234&search_term_lp=in%20search%20of%20essential%20nutrients)
  + [Lesson 2: Properties of Soils](http://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=235&search_term_lp=properties%20of%20soils)
  + [Lesson 3: Plant-Soil Interactions](http://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=236&search_term_lp=plant-soil)
  + [Lesson 4: Plant Nutrient Deficiencies](http://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=237&search_term_lp=plant%20nutrient%20deficiencies)
  + Lesson 5: Fertilizers and the Environment

**Suggested Companion Resources**

* [Phosphate Mining Video](https://www.agclassroom.org/teacher/matrix/resources.cfm?rid=756) (Multimedia)
* [Potash Mining Video](https://www.agclassroom.org/teacher/matrix/resources.cfm?rid=757) (Multimedia)
* [Unlock the Secrets in the Soil](https://www.agclassroom.org/teacher/matrix/resources.cfm?rid=769) (Website)

**Sources/Credits**

* Nutrients for Life Foundation
* BSCS-Biological Science Curriculum Study
* Reviewed by Smithsonian Institution

 **Sustainable Crop Production**

Sustainable crop production is a way of growing or raising food in an ecologically and ethically responsible manner.  This includes adhering to agricultural and food production practices that do not harm the environment, that provide fair treatment to workers, and that support and sustain local communities.  Sustainable crop production is in contrast to industrial crop production, which generally relies upon monocropping (growing only one crop in a large area of land), intensive application of commercial fertilizers, heavy use of pesticides, and other inputs that are damaging to the environment, to communities, and to farm workers. In addition, sustainable crop production practices can lead to higher yields over time, with less need for expensive and environmentally damaging inputs.

* [Read more about industrial crop production](http://www.sustainabletable.org/804/industrial-crop-production)
* [Read more about sustainable food and health](http://www.sustainabletable.org/271/food-personal-health)

**How Are Sustainable Crops Grown?**

Sustainable crops are grown in a different manner from industrial crops. Sustainable crop farmers focus on ensuring that their farming practices can be sustained over time and do not cause undue damage to the environment.  A number of different principles are involved in sustainable crop production, including multicropping. Multicropping is an agricultural method of planting multiple species on one piece of land, either during the same growing season or in successive growing seasons. Multicropping can involve:

* Crop rotation: the practice of changing what is planted in a particular location on a farm from season to season.
* Intercropping: a method of planting two or more crops of differing characteristics in close proximity to reduce weeds; to encourage plant diversity in order to avoid insect and pest infestation; and to provide shade, nitrogen fixation, or other benefits to the plants being grown.  Intercropping includes companion planting and the use of cover crops.

Multicropping is in direct contrast to monocropping, in which large tracts of land are planted with a single crop.  Multicropping has a number of environmental benefits, including:

* Increased yields. Monocropping has been shown to decrease yields over time, while multiculture practices such as crop rotation and the use of cover crops can increase yields by reducing pests, improving soil health, and increasing water retention.
* Decreased pest susceptibility. Multicropping reduces extreme vulnerability to a wide array of pests, including weeds, insects, fungi, and other organisms. The lack of genetic diversity on monocropped farms means that a single pest can decimate large areas of cropland.
* Increased biodiversity.  Multicropped farms have a number of species that may interact in a meaningful way, such as providing shade for other crops, providing nitrogen fixation for the soil, or repelling pests.

**Minimal to No Pesticide Use**

Pesticides are substances that destroy various agricultural pests, including weeds (herbicides), insects (insecticides), bacteria (microbicides), and fungi (fungicides). Industrial crop production relies heavily upon pesticides, in part because the practice of monocropping increases vulnerability to pests. Unfortunately, pesticides can cause health problems in farm workers who apply the chemicals and who harvest the crops, and in consumers who eat foods with pesticide residues.  Various pesticides have been linked to certain types of cancer, to neurological problems, and to other health problems.  Pesticides also cause environmental damage such as water pollution and soil contamination.  The use of pesticides can also make pest control more difficult; as in the case of insect control, insecticide use can have the unintended consequence of eliminating insect predators that prey upon pest insects, and can also increase pesticide-resistance in pest insects.  In addition, pesticides have been shown to cause declines in pollinators and other beneficial insects that are critical to the health of agricultural systems.

Sustainable crop production greatly reduces pesticide use; in fact, many sustainable farmers do not use commercial pesticides at all. A number of alternatives to commercial pesticides can be used to protect crops from damage by pests such as weeds and insects, including:

* Integrated pest management: Integrated pest management, or IPM, is a pest-management system that integrates several pest-management approaches. Principles of IMP include monitoring and identifying pests before they become a threat; intercropping and crop rotation to reduce buildup of pests; preventing pests before they reach damaging levels; use of plants that are natural insect repellants; and managing pests using a tiered system of control, including manual removal (e.g., weeding or trapping).  Pesticides are generally used sparingly and only when other methods fail.
* Intercropping and companion planting: Intercropping is a method of planting crops in close proximity in order to reduce weeds, to encourage plant diversity in order to avoid insect and pest infestation, and for other agricultural reasons. Companion planting is a related method that capitalizes on plants that are natural pest repellants (for example, marigolds), plants that are more attractive to pests than the primary crop, or plants that attract beneficial insects.
* Mulching, groundcover, and manual control: Mulching is the process of spreading organic or mineral (rock) material to manually control the growth of weeds.  Groundcovers (also known as “living mulch”) are generally plants that that are grown close to the ground below the main crop in order to control weeds. Weeds and insects may also be prevented by manual removal, though this is a highly labor-intensive process.
* Release of beneficial insects and organisms: There are a number of beneficial insects and organisms that, when released, destroy harmful pests. Beneficial insects include predators such as ladybugs; beneficial organisms include nemotodes (microscopic worms) that are used to destroy the larvae of pests.

**Focus on Soil Health**

Soil health is a critical component of sustainable agriculture and comprises a number of different growing practices and principles.  FThere is also some evidence that sustainably grown plants may be higher in vital macro- and micronutrients, resulting from increased soil health as a direct consequence of organic growing methods and sustainable practices.  Some of these practices are outlined below:

Organic Fertilizer Use

Inorganic (commercial) fertilizers are synthetically created (or mined) for the purpose of adding nutrients plants need to grow to the soil.  The practice of monocropping and the lack of crop rotation on industrial farms result in the greater need for soil augmentation with synthetic fertilizers.  Commercial fertilizer use can impair soil health over time, resulting in the need for additional application of inorganic fertilizers. It may also cause soil acidification and soil contamination with heavy metals.  In addition, commercial fertilizers are a primary source of water pollution, causing algal blooms and dead zones in bodies of water throughout the US.  The production of inorganic fertilizers also requires large quantities of fossil fuels.

Alternatives to synthetic fertilizer use include compost (decomposed organic matter), animal manure, seaweed, and worm castings. Each of these products can help boost soil health through the introduction and maintenance of healthy soil organisms and micronutrients. Organic fertilizers increase soil biodiversity and have been shown to increase the uptake of nutrients by plants.  There is also evidence that use of organic fertilizers improves the nutrient value of the plants themselves.

**Crop Rotation, Intercropping, & Mulching**

Intercropping, crop rotation, and mulching are other sustainable crop production methods that help replenish the soil. Intercropping and crop rotation can improve soil health by introducing plants that fix nitrogen (a process that pulls nitrogen from the air and releases it into the soil) or plants that can be turned under after their growing season is complete to add additional nutrients to the soil.  Crop rotation also generally increases yields, while monocropping has been implicated in declines in crop yield and loss of nutrients from the soil.  Rotating crops allows soil to “rest,” that is, to replenish its vital micronutrients, microbes, and other important components.  Mulching can reduce soil erosion and help retain critical soil moisture.

**Less to No Tilling of Soil and Reduction of Heavy Machinery Use**

Industrial agricultural operations use tilling (plowing) to create rows, loosen soil, and to remove weeds. Sustainable farms use no-till methods or minimize tilling in order to protect the soil.  [F](http://www.sustainabletable.org/library/view.php?fn=3702)No-to-minimal till methods can reduce soil erosion and compaction, increase aeration (critical for root growth and function), and reduce loss of water and critical nutrients.  [F](http://www.sustainabletable.org/library/view.php?fn=3174)

Large industrial operations also use heavy machinery to till the soil, to plant, and to harvest. Sustainable producers limit (or eliminate) use of heavy machinery, which conserves non-renewable resources (e.g., oil) and can decrease soil compaction and erosion.

* [Read more about soil](http://www.sustainabletable.org/207/soil-quality)

**Choosing Sustainable Seeds and Plant Varieties**

Seed and plant variety selection is an important component of sustainable crop production. Large industrial operations generally select plant varieties for yield, ease of mechanical harvest, fast growth, and/or ability to be transported over long distances, rather than for flavor or nutritional content.  The focus on hybridization and monocropping in industrial crop production has resulted in a loss of biodiversity on farms and a decline in nutrients in a number of different staple crops.

Heirloom crop varieties are plants that were grown in the past and generally not used for industrial crop production.  Prior to the widespread introduction of hybrid seeds (in the US starting in the 1950s and accelerating in the 1970s), heirloom varieties were the predominant type of crops grown.  Heirloom varieties are generally chosen for taste and nutritional value and have frequently been bred to be acclimated to a particular environment, thus making them more resistant to local pests and better suited to the local climate. In addition, heirloom seeds can be saved from year-to-year, while most hybrid varieties are sterile.  This forces producers to purchase new seed stock every year – and seed stock is generally controlled by a handful of large agribusinesses.  While sustainable crop production does not necessarily eschew hybrid varietals, crop varieties are chosen primarily for taste, nutritional content, and adaptability to a particular environment.

Finally, in industrial crop production operations, genetically engineered (GE) crop varieties may be grown to control pests, to allow greater application of herbicides, or to conform to perceived consumer demand (e.g., an apple variety that does not brown when cut).  Sustainable agriculture rejects GE varietals due to their potential adverse environmental impacts, the uncertainty of their healthfulness, and the large amount of inputs required for their production (e.g., commercial fertilizers, herbicides, etc.).

**Practicing Water Conservation and Sustainable Irrigation**

Sustainable crop production practices include methods of water conservation and sustainable irrigation. Over-irrigation causes the salinization of soil, which can lead to declines in yield.  Additionally, in many agricultural areas, aquifers used for irrigation are depleting rapidly.  Sustainable agriculture water conservation practices include low volume irrigation, rainwater catchment, and the planting of drought-resistant crops or crops that have been bred for a particular environment.

* [Read more about water and agriculture](http://www.sustainabletable.org/267/water-quality)

**Other Methods of Sustainable Crop Production**

In addition to traditional farm planting, there are a number of sustainable agricultural practices that focus on growing food sustainably in ways best suited to a particular location or environment, including:

* Aquaponics: Raising aquatic animals such as fish in a symbiotic environment with hydroponically grown plants.
* Agroforestry: A type of intercropping that involves growing trees and shrubs alongside crops to the mutual benefit of both.
* Permaculture: An agricultural philosophy that combines several agricultural principals, including agroforestry, intercropping, mulching, and rainwater catchment.
* Rooftop farms and other methods of urban agriculture: Bringing food production closer to communities by growing on city rooftops, in small backyard plots, and in vacant lots.
* [Read more about innovative agriculture](http://www.sustainabletable.org/251/innovative-agriculture)

**Socioeconomic Factors in Sustainable Crop Production**

Sustainable crop production entails not only environmental responsibility, but also socioeconomic responsibility, which involves ensuring fair treatment of workers, supporting farm communities, and sustaining local food systems.

In many industrial operations, farm workers are subjected to harsh conditions, including toxic exposure to pesticides and other chemical inputs, dismal living conditions, and extremely low pay.  They also frequently lack legal protections provided to workers in other sectors.  Sustainable farm managers strive to treat workers justly, including paying a fair wage for work.

Monoculture farms and their surrounding communities are also economically vulnerable to crop loss (e.g., by drought, flooding, or pest damage) and fluctuations in supply and demand.  Diversifying farms through sustainable multiculture practices can help reduce this economic vulnerability.

Finally, sustainable crop production aims to support local communities through the protection and maintenance of farmland, by ensuring that money spent for farm inputs is distributed throughout the local community, and by serving as an integral component of local food systems.

* [Read more about farm workers](http://www.sustainabletable.org/273/workers)
* Read more about local farm communities and economics
* [Read more about local food systems](http://www.sustainabletable.org/254/local-regional-food-systems)

Quick Application Notes:

* Use activity 3 if time permits, but do not rush to fit it in.
* Summarize all of the required readings for background knowledge and display it.