PROJECT FEED 1010

ISB Systems Education Experiences

CURRICULUM SERIES: MODELING SUSTAINABLE FOOD SYSTEMS

FOOD SECURITY (FS) MODULE

Students take an interdisciplinary approach to understand a global issue. The driving question: "*How can we think and act on a systems level to produce and consume food resources that will be environmentally sustainable and sufficient for global needs*?" Students learn that systems thinking is helpful in identifying influences and interactions within the food security system. After critically examining the environmental tradeoffs involved with various food production techniques, students engineer a system, such as an aquaponic system, to evaluate the potential of scaling up aquaponics to fill the future food gap. Next, students examine the origins of food and resources required to produce it. Throughout this module, student groups investigate various aspects of the food crisis in a specific country, which culminates in a UN council meeting to propose a solution.

COURSE INTEGRATION

Statistics, Human Geography, Biology, AP Biology, Environmental Systems, AP Environmental Science, Agriculture, Social Studies

LESSON 1: INTRODUCTION TO FOOD SECURITY

TIME

50 minutes - 1 class period

STANDARDS

- NGSS PE: HS-LS2-1; DCI: LS2.A; SEP: Using Mathematics and Computational Thinking; CC: Scale, Proportion, and Quantity
- NGSS PE: HS-ESS3-1; DCI: ESS3.A; SEP: Constructing Explanations and Designing Solutions (CEDS); CC: Cause and Effect (C&E)
- NGSS PE: HS- ESS3-3; DCI: ESS3.C; SEP: Using Mathematics and Computational Thinking; CC: Influence of Engineering, Technology, and Science (ETS)

OBJECTIVES

What students learn

Food security is defined by 3 pillars, and it is influenced by many factors including poverty, geography, society, climate, and politics. 11% of all people worldwide go hungry each day. This is a complex, global problem that needs addressed in *their* lifetime.

What students do

Students create their own definition of food security using knowledge from class discussions. They apply statistics to compare and contrast food security in countries around the world and collaborate with team members to investigate one country with food insecurity.

LESSON 2: CRITICALLY EVALUATING FOOD PRODUCTION TECHNIQUES

TIME

90 minutes - 2 class periods

STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: Stability and Change (S&C)
- NGSS PE: HS-ESS3-2; DCI: ESS3.A; SEP: Engaging in Argument from Evidence; CC: Influence of ETS
- NGSS PE: HS-ESS3-4; DCI: HS-ESS2.C; SEP: CEDS; CC: Influence of ETS
- NGSS PE: HS- ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

OBJECTIVES

What students learn

Conventional farming methods are limited by resource dependence, while others may better adapted to our increasing population and changing climate. Determining the best solution is highly dependent upon the needs, resource availibility, and climate of each region.

What students do

Students respond to *Food for Thought* video and research four food production methods to evaluate their impact and efficiency. Students assign sustainability scores to each method, propose the "best" method in a presentation, then demonstrate understanding by justifying the most effective method for their assigned country.

APPLICATION 1: DESIGNING, CONSTRUCTING, AND RE-ENGINEERING A SYSTEM

TIME

90 minutes - 2 class periods, weekly monitoring

STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-ESS3-4; DCI: ESS3.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-ETS1-4; DCI: ETS1.B; SEP: Using Mathematics and Computational Thinking; CC: Systems and Systems Models
- Extensions: NGSS PE HS-LS2-4 and HS-LS2-5

OBJECTIVES

What students learn

Students review the nitrogen cycle and how it can be engineered into a resilient system for growing food. This gives students context for better understanding the resilience of natural ecosystems and the importance of system stability. Students learn modeling can help inform solutions to global food insecurity.

What students do

Students apply systems biology approaches to illustrate an aquaponic network and then design a model system. They scale up an aquaponic system to apply to a food system with limited water resources. Students analyze data from ISB systems or their own model systems to build and carry out an investivation.

LESSON 3: WHO CARES? STAKEHOLDERS!

TIME
50 minutes - 1 class period

STANDARDS
- NGSS PE: HS- ESS3.1; DCI: ESS3. A; SEP: Constructing Explanations and Designing Solutions; CC: C&E
- NGSS PE: HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS
- CCSS ELA-LITERACY.RI.11-12.1 Key ideas and details in text

OBJECTIVES
What students learn

Stakeholders are people or organizations with a vested interest in an issue. Students recognize the influence of stakeholders in decision making and the challenges of coming to a consensus. Many stakeholders are involved in the food security crisis.

What students do

Students are assigned the role of a stakeholder. After examining the stakeholder's information, students introduce themselves through presentations and generate a response to a critical question: *will an increase in food production alone solve the global food crisis?*

LESSON 4: FOOD SECURITY AS A SYSTEM

TIME
90 minutes - 2 class periods

STANDARDS
- NGSS PE: HS-LS1-3; DCI: LS1.A; SEP: Planning and Carrying Out Investigations; CC: S&C
- NGSS PE: HS-LS2-7; DCI: LS2.C & LS4.D; SEP: CEDS; CC: S&C
- NGSS PE: HS-LS2-8; DCI: LS2.D; SEP: Engaging in Argument from Evidence; CC: Cause and Effect
- NGSS PE: HS-ESS3-1; DCI: ESSE.A; SEP: CEDS; CC: C&E
- NGSS PE: HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

OBJECTIVES
What students learn

Students learn the 14 habits of a systems thinker and the 6 steps used to analyze systems, along with strategies for illustrating systems. They identify interactions in the food security system as well as the "tipping points" that lead to irreversible change.

What students do

Students relate systems thinking habits to everyday situations, use a variety of diagrams to visualize systems, work collaboratively to create a large causal loop diagram of food security, and evaluate the stability of our food production system by assessing interactions, feedback loops, and tipping points.

LESSON 5: WHY DON'T WE JUST GROW MORE?

TIME
50 minutes - 1 class period

STANDARDS
- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-LS4-6; DCI: HS-LS4C & HS-LS4D; SEP: Using Mathematics and Computational Thinking; CC: C&E
- NGSS PE: HS-ESS2-5; DCI: HS-ESS2C; SEP: Developing and Using Models; CC: Energy and Matter
- NGSS PE: HS-ESS3-1; DCI: HS-ESS3A; SEP: CEDS; CC: C&E
- NGSS PE: HS-ESS3-4; DCI: HS-ESS3C; SEP: CEDS; CC: S&C & ETS
- NGSS PE: HS-ETS1-3; DCI: ETS1.B; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

OBJECTIVES
What students learn

Students recognize that solving the global food security crisis is complex and that decisions made to address it will affect all stakeholders. Students also learn some network nodes have more influence than others.

What students do

Students work in groups to analyze "The Great Balancing Act", a working paper from the World Resources Institute. In partners, students analyze the impact each stakeholder would have in each of the suggested scenarios and connect the concepts to the network.

LESSON 6: WHERE DOES OUR FOOD COME FROM?

TIME
60-90 minutes - 1-2 class periods

STANDARDS
- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-LS4-6; DCI: LS4.D; SEP: Using Mathematics and Computational Thinking; CC: C&E
- NGSS PE: HS- ESS3-2; DCI: ESS3.A; SEP: Engaging in Argument from Evidence; CC: Influence of ETS
- NGSS PE: HS-ESS3-4; DCI: ESS3.C; SEP: CEDS; CC: S&C; ETS
- NGSS PE: HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS
- NGSS PE: HS-ETS1-2; DCI: ETS1.C; SEP: CEPS

OBJECTIVES
What students learn

Students understand not only the economic, but also the environmental costs associated with production and consumption of food products and how external variables can affect them. External costs may not show up on the price tag!

What students do

Students play a game and become business people who are challenged to grow ingredients to make sustainable food products in the face of economic difficulties and changing environmental conditions. Students strategize and make decisions to build a food system that is profitable while also balancing their system's impact on the environment.

LESSON 7: UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION SUMMIT

TIME

Part I (50 min) - Defining problem and gathering evidence
Part II (50 min) - Finding solutions and building consensus
Part III (50 min OR homework option) - Testing a solution

STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS- ESS3-4; DCI: ESS3.C; SEP: CEDS; CC: S&C; Influence of ETS
- NGSS PE: HS-ETS1-2; DCI: ETS1.C; SEP: CEDS; CC: Influence of ETS
- NGSS PE: HS-ETS1-3; DCI: ETS1.B; SEP: CEDS; CC: Influence of ETS
- Common Core Science Standards: 1) ELA/Literacy: Integration of Knowledge and Ideas: ELA-LITERACY.RH.11-12.7; 2) Mathematics: MP.2 Reason abstractly and quantitatively (HS-ETS1-1), (HS-ETS1-3), (HS-ETS1-4); 3) Using Mathematics and Computational thinking
- AP Environmental Science standards 11, 16, 17

OBJECTIVES

What students learn

Students learn that a thorough understanding of the complexity of the global food production system is necessary for designing effective solutions to food insecurity. They will learn the importance of negotiation and compromise in reaching consensus in the global community, and the role that the UN plays in addressing international issues. Students also learn how to outline an effective argument, and to support their claims with evidence and logic.

What students do

Students conduct a UN Summit, working collaboratively to come up with practical and realistic solutions to food insecurity in three different countries. They will synthesize information and apply skills learned in FS lessons 1-6, both when outlining major food security challenges as well as when designing their solutions. Finally, they will apply the claim-evidence-reasoning approach in critically evaluating the final four UN Summit Actions developed by the class.

FOOD SECURITY MODULE ICON KEY

Infer global patterns and trends in food insecurity using geography

Apply math and statistics to quantify relationships and population parameters

Examine relationships between geography, climate, and politics and food security

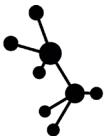
Collaborate with peers through group activities and class discussions

Synthesize information from online resources to propose solutions

Examine and analyze case studies through video clips to inspire innovation

Present and defend opinions and/or findings to an audience

Propose a plan for creating and evaluating a food production system



Use systems thinking to infer effects of perturbations within a system

Design and construct a model to demonstrate systems biology concepts

Compile information from text to make inferences and draw conclusions

Evaluate the impact of decisions and solutions on global processes and societies

Apply cost-benefit analyses and business strategies to sustainably support the economy

LESSON 1: INTRODUCTION TO FOOD SECURITY

THE BIGGER PICTURE

Food security is a foreign concept to many Americans. Most believe that chronic hunger and malnutrition happens only to people in developing nations or to the homeless. In reality, 1 in 6 people in America go hungry every day and are not food secure. To some students, food insecurity is a reality, therefore this is a subject that must be approached with great sensitivity and care. Throughout the lesson students will develop and refine their understanding of food security using online resources, videos and class discussion to help guide their thinking. This concept is the introduction to the unit and will be addressed in future lessons associated with the unit, so it is important that the students get a solid understanding of the concept. They are able to compare different countries and analyze what food security issues they have based on the three pillars using global statistics. The lesson ends by introducing students to the UN council meeting that will take place at the end of this unit, and answering questions to prepare for it in the *Building Your Case* worksheet.

OBJECTIVES

What students learn

Food security is defined by 3 pillars, and it is influenced by many factors including poverty, geography, society, climate, and politics. 11% of all people worldwide go hungry each day. This is a complex, global problem that needs addressed in *their* lifetime.

What students do

Students create their own definition of food security using knowledge from class discussions. They apply statistics to compare and contrast food security in countries around the world and collaborate with team members to investigate one country with food insecurity.

TIME

50 minutes - 1 class period


STANDARDS

- NGSS PE: HS-LS2-1; DCI: LS2.A; SEP: Mathematics and Computational Thinking; CC: Scale, Proportion, and Quantity
- NGSS PE: HS-ESS3-1; DCI: ESS3.A; SEP: Constructing Explanations and Designing Solutions; CC: Cause and Effect
- NGSS PE: HS- ESS3-3; DCI: ESS3.C; SEP: Mathematics and Computational Thinking; CC: Influence of ETS

PREREQUISITES

Students should have a basic understanding of middle school mathematics - percentages, ratios, and proportional relationships.

BEFORE CLASS

Gather materials: Optional whiteboard for discussion; index cards numbered 1-10, map of the world; world hunger map; Food Security Vocabulary PowerPoint; 3 Pillars PowerPoint; Building your Case worksheet; Further Background section (below). All of the *Modeling Sustainable Food Systems* resources are on the SEE website: isbscience.org.

TEACHER INSTRUCTIONS

You will be using a few online, interactive maps to help students understand the overwhelming number of people who are undernourished and food insecure around the world. The following data comes from the UN's World Food Program using their most recent data from the Food and Agricultural Organization (FAO). Your challenge is to take global statistics and translate it to the number of students. It would be beneficial to read the Further Background section (below) before teaching this.

Hunger statistics that can be used for this activity

- Globally - 795 million hungry people of a population of 7,300 million = 11 %
- USA proportion of undernourished <5%
- North Korea (Democratic People's Republic of Korea) proportion of undernourished = 42%
- South Korea (Republic of Korea) proportion of undernourished <5%
- Dominican Republic proportion of undernourished = 12%
- Haiti proportion of undernourished = 53%

1. Warmup: Show Food Security Vocabulary PowerPoint. Have students hypothesize what they think "food security" means. There is no right or wrong answer at this point. They can write their thoughts in a notebook or share outloud. *Do not give them the correct definition yet!*
2. Before introducing the lesson, pass out an equal number of index cards labeled 1-10, one per student. Extra student(s) can be employed as counters during the activity. If you have more than 10 students, make additonal cards numbered 1-10.
3. Display a map of the world on your projector. Give the students the global hunger statistics and have them determine which combination of cards distributed equals 11%. This equates to about 1 in 10 students or 2 in 20 students that go hungry each day. Students with a "1" or "2" raise their hands depending on the number of students in your class.
4. Ask students to predict what the % of undernourished people is in the USA or Canada. Tell them 4% is a high estimate and have them determine which combination of cards distributed that equals 4% (less than 1 in 10 people, ~1 in 20 people).
5. It isn't always about geographic location; countries with certain policies/politics/geography all influence food security. The United States even has problems with hunger. Point out two sets of countries that share common borders such as Haiti and the Dominican Republic, or North and South Korea. You can use any combination of countries of your choosing off of the FAO's World Hunger Map.

TEACHER INSTRUCTIONS CONTINUED

6. Continue having students determine which combination of cards distributed equals the % undernourished in those countries.
7. Display the high resolution UN World Hunger Map (http://www.wfp.org/content/hunger-map-2015) and ask if students see any patterns. Hypothesize a few reasons these patterns may exist. At this point, many issues/ideas should begin to surface (political system, geography, state of the country's economy, infrastructure, climate, etc).
8. Discussion: there are a number of things that keep people from having enough food. What are some things that prevent them from getting enough food? When students start listing ideas, link them to the categories of "food availability", "food access", and "food use" *but don't yet reveal the definition of food security*.
9. Show the 3 Pillars PowerPoint ask the students to brainstorm (in pairs) the factor inhibiting food supply demonstrated on each slide.
10. Ask the students to revisit their definitions of food security following slide 8. Is there anything they want to change or add? Proceed to slide 9, which outlines the main questions we need to think about when evaluating food security, and then review the 3 pillars of food security and the World Summit of 1996 definition with the class on slides 10 and 11.
    - Food availability: sufficient quantities of food available on a consistent basis
    - Food access: having sufficient resources to obtain appropriate foods for a nutritious diet
    - Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation
11. Start a discussion: of the countries we looked at, do you think these countries are missing all of these pillars? Can you be food secure and only have 2 pillars? Students should recognize that, even if a country is missing one pillar, it would still be considered food insecure.
12. Lead a class discussion to **come up with a class definition of food security,** and then compare that to the definition from the World Food Summit (3 Pillars PowerPoint, Slide 11). Lead the class into the idea that food security is not just an American issue, but worldwide, and is not just about growing more food or eliminating poverty.
13. Formative assessment: Open the Food Security Vocabulary PowerPoint. Is the answer to food security simply growing more food? Justify your answer. Students will revisit their answers in Lesson 3.
14. Hand out the Building your Case student document and complete questions for Lesson 1. Split students up into up to 3 groups to represent 3 different countries - North Korea, Nambia, and Haiti. If you have less than 25 students, split up students into 2 groups and choose 2 countires. Within those country groups, students should split up into smaller groups of 3-4 to complete the Building Your Case questions each day. To save time, Lesson 1 questions (country research) can be assigned as homework.

BUILDING YOUR CASE ACTIVITY

Students now recognize that many countries around the world, including the United States, suffer from food insecurity. You and your students will be using the *Building your Case* student and teacher documents at the end of each lesson in this curriculum series. This activity will guide students through the process of investigating a food insecure country and creating a proposal to aid the UN in solving the crisis in that country. Each lesson will introduce more information to students pertaining to the global food crisis and sustainable food production. After learning new material in each lesson, students will apply it to questions in the *Building your Case* worksheet.

MATH EXTENSION ACTIVITY

This optional extension activity (~15 minutes) gives students the opportunity to practice calculating percentages and growth rates and recognize the implications of population growth on food security. This activity should follow step 11 in the teacher instructions.

1. Remind students that currently 11% of the global population is undernourished.
2. Open link to Figure 1 from Resources and select "world" from the dropdown menu. Either explain the graph or allow students to gather information from the key and figure summary.
3. Using the figure, have students determine the percent growth of the Earth's population from today to 2050.

   Example Calculation:
   - Current global population: 7300 million
   - Projected global population in 2050: 9500 million
   - What is the percent increase in population?
   - (9500 – 7300)/7300 * 100 = 30% increase
4. Using this % increase and current hunger trends, how many hungry humans will there be in 2050?

   Example Calculation
   - Current % hungry people globally: 11%
   - Projected global population in 2050: 9500 million
   - Number of hungry people: 9500 * 0.11 = 1045 million (approximately 3x USA population)
5. Is this an exaggerated or conservative value? Explain.

FURTHER BACKGROUND

Food security is a complex sustainable development issue, linked to health through malnutrition, but also to sustainable economic development, environment, and trade. There is a great deal of debate around food security with some arguing that:

- There is enough food in the world to feed everyone adequately; the problem is distribution.
- Future food needs can - or cannot - be met by current levels of production.
- National food security is paramount - or no longer necessary because of global trade.
- Economic Globalization may, or may not, lead to the persistence of food insecurity and poverty in rural communities.
- Increasing food production to meet future population demands may or may not lead to increased negative environmental impacts.
- Climate change may or may not make agricultural production more difficult
- Issues such as whether households get enough food, how it is distributed within the household and whether that food fulfils the nutrition needs of all members of the household show that food security is clearly linked to health.

Agriculture remains the largest employment sector in most developing countries and international agriculture agreements are crucial to a country's food security. Some critics argue that trade liberalization may reduce a country's food security by reducing agricultural employment levels. Concern about this has led a group of World Trade Organization (WTO) member states to recommend that current negotiations on agricultural agreements allow developing countries to re-evaluate and raise tariffs on key products to protect national food security and employment. They argue that WTO agreements, by pushing for the liberalization of crucial markets, are threatening the food security of whole communities.

LESSON 1: INTRODUCTION TO FOOD SECURITY

RESOURCES

- SEE website: isbscience.org
  - Food Security Vocabulary PowerPoint
  - 3 Pillars PowerPoint
  - Building your Case Worksheet
- FAO's World Hunger Map: http://www.fao.org/hunger/en/
- UN World Hunger Map: http://www.wfp.org/content/hunger-map-2015
- Source of Statistics: UN's World Food Program (http://www.wfp.org/)
- Figure 1: UN Department of Economic and Social Affairs (https://esa.un.org/unpd/wpp/Graphs/Probabilistic/POP/TOT/)
- Reliable websites students can use to research their country information:
  1. https://www.cia.gov/library/publications/the-world- factbook/
  2. http://data.worldbank.org/country
  3. http://data.un.org/CountryProfile.aspx
  4. http://wits.worldbank.org/CountrySnapshot/en/NAM/textview
  5. http://www.fao.org/faostat/en/#country/93
  6. http://www.fao.org/faostat/en/#country/116
  7. http://www.fao.org/faostat/en/#country/147

LESSON 1: INTRODUCTION TO FOOD SECURITY

BUILDING YOUR CASE

Globally, one in nine people in the world today (795 million) are undernourished. The vast majority of the world's hungry people live in developing countries, where 12.9% of the population is undernourished. Throughout this lesson, you will be the voice for one of these countries, where they so desperately need a solution to the food crisis. You will be preparing a proposal for the United Nations (UN) that clearly describes your country's plan to eradicate food insecurity, and will present it to the UN council at the end of this unit. You will answer the following questions after learning more information in each lesson. This will help you build your case.

LESSON 1: INTRODUCTION TO FOOD SECURITY

You and your group are representatives of the following country _____

Fellow country representatives _____

With your smaller team of country representatives, collect background information about your country:

1. Annual rainfall _____
2. Current population size _____
3. Land area _____
4. Population density (people per square kilometer) _____
5. Population growth rate _____
6. Exports (price and main materials) _____
7. Imports (price and main materials)_____
8. Per capita income _____
9. Political issues _____
10. Cultural and/or religious notes _____
11. Main transportation and any difficulties _____
12. Land use _____
13. Water resources and use for agriculture _____
14. Fertilizers (use, import/export) _____
15. Current environmental issues _____
16. Staple food crop and dietary preferences _____
17. Primary crop production _____
18. Primary type of farming _____
19. Land area dedicated to growing crops (compared to other land use) _____
20. Biomes _____
21. Climate _____
22. Other notes:

LESSON 2: CRITICALLY EVALUATING FOOD PRODUCTION TECHNIQUES

1. You just investigated various strategies for growing food. Based on your country's demographics and needs, which growing technique would you choose? Justify your answer. Questions to consider: does the system rely on resources that are limited? How does the system deliver food to people?

2. Where and how will the system be used? Are their limited resources such as water or adequate healthy soils? Explain your answer.

LESSON 3: WHO CARES? STAKEHOLDERS!

1. Which stakeholder are you representing? _____
2. As a stakeholder, you care about the outcome of the decision to solve the food security crisis in your country as it will affect you in a number of ways. Do you believe we can simply grow more food to solve this issue in your country? Explain.

3. After meeting with the other stakeholders in your country, were you able to come to a consensus about whether or not simply growing more food would solve the crisis in your country? If so, how did you come to that conclusion? If not, what were some of the points of disagreement?

BUILDING YOUR CASE - STUDENT (CONTINUED)

LESSON 4: FOOD SECURITY AS A SYSTEM

1. Draw a food security network for your country that will help the UN better understand the very complex nature of your country's crisis.

2. Choose 2 nodes that could be changed in some way that would have an effect on the overall issue. Explain.

LESSON 5: WHY DON'T WE JUST GROW MORE?

1. Choose 2 menu items from The Great Balancing Act and describe how your stakeholder would be affected by the proposed change in your country. Would you benefit or not? Explain.

2. Which 2 menu items do you believe most other stakeholders in your country would agree would most benefit your country's crisis? Justify your choices.

LESSON 6: WHERE DOES OUR FOOD COME FROM?

1. Where does most of the food eaten in your country come from? What would happen if a drought diminished the supply of that food? How would that affect the price? Explain.

2. How could your country become more resilient to the effects of environmental catastrophes on the food they depend on to survive? Provide 2 solutions and explain why they would help.

3. Do you believe your country has a relatively small or large environmental impact due to the primary food items they eat? Justify your answer.

LESSON 2: CRITICALLY EVALUATING FOOD PRODUCTION TECHNIQUES

THE BIGGER PICTURE

A variety of agricultural production systems are used to produce food around the world. Some systems rely on the continuous addition of resources, while others use resources more efficiently. In this lesson, students evaluate various food production techniques in terms of their environmental sustainability and potential for producing enough food to feed a growing world population. Students first respond to a video which introduces the inspirational movement of young people using agricultural innovation to address the global food crisis. Students then read articles about five different agricultural production systems, assign sustainability scores to food production techniques, and present their findings. Through teacher-led discussion, the class determines the most sustainable method of food production. Students then justify the best food production technique for the country they investigated in Lesson FS1. Students transition to the next activity (Lab FS1: Creating an Efficient System) by reviewing abiotic and biotic factors needed by each system to produce food.

OBJECTIVES

What students learn

Students deepen their understanding of sustainability in the context of food production and become familiar with the techniques used to grow food. Conventional methods are resource dependent; others may better accomodate our population and changing climate. Solutions are dependent upon regional needs, resource availability, and climate.

What students do

Students respond to the "Thought for Food" video and research 5 food production methods to evaluate their impact and efficiency. Students assign sustainability scores to each method, propose the "best" method in a presentation, and demonstrate understanding by justifying the most effective methods for their assigned country from Lesson FS1.

TIME

60 - 90 minutes (1-2 class periods) depending on optional activities

STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: Constructing Explanations and Designing Solutions (CEDS); CC: Stability and Change
- NGSS PE: HS-ESS3-2; DCI: ESS3.A; SEP: Engaging in Argument from Evidence; CC: Influence of Engineering, Technology, and Science (ETS)
- NGSS PE: HS-ESS3-4; DCI: HS-ESS2.C; SEP: CEDS; CC: Influence of ETS
- NGSS PE: HS- ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

PREREQUISITES

Students should understand the basic cycles of matter (including the nitrogen cycle) and energy transfer in ecosystems, as well as ecosystem dynamics and functioning. Students should also be familiar with the concept of food security.

BEFORE CLASS

Gather materials (see "Resources" section): "Thought for Food" video, student video guide handout, video teacher key, Food Security Vocabulary powerpoint, Lesson 2 Student Handout (Graphic organizer), Lesson 2 Handout Teacher Key, and Building Your Case worksheets. Students should either have laptops to read the food production system articles or these articles should be printed out prior to class. All of the *Modeling Sustainable Food Systems* resources are on the SEE website: isbscience.org.

TEACHER INSTRUCTIONS

1. **Warm-Up:** Students come up with a definition for sustainability, which will provide a framework within which they can evaluate the different food production systems.
   - Show the vocabulary for Lesson 2 using the Food Security Vocabulary PowerPoint. Have students brainstorm the meaning of "sustainability". Show the 3 Pillars PowerPoint to refresh students' memories of food security, and ask students to discuss how food security might be related to sustainability. The purpose of this lesson is to learn about different agricultural systems and to evaluate their degree of sustainability, while keeping in mind the connection between agriculture and food security.
   - **Definitions:**
     - Sustainable Development: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987)
     - Sustainable: "Of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged" (Merriam-Webster dictionary)
2. **Optional Activity - defining the problem:** Through watching a 20-minute inspirational video, students learn more about the global food crisis and how young people are coming up with innovative ways to improve our current methods of food production.
   - Pass out the video guide for "Thought for Food" (see Resources), and have students preview the questions.
   - Show "Thought for Food" (~20 minutes), a documentary on young innovators tackling the challenge to feed 9 billion humans.
   - After watching the video, ask students to name some of the main challenges we are facing with our current food production, based on what they already know or what they learned in the film (e.g. water storage, land shortage, agricultural runoff, population growth, etc). How do these challenges affect food security? Which of the 3 Pillars of food security discussed in FS Lesson 1 are the innovation teams each addressing?
3. **Transition to the next activity,** by asking students to discuss the following:
   - What are the ways in which we currently produce food? They may mention factory farms, commercial agriculture, organic farms
   - Review: What are the basic resources necessary for producing food? Land, soil, sunlight, nutrients, water, etc.
   - What are some criteria we could use to decide how successful and efficient an agricultural system is? What do you think an ideal food production system would look like?

TEACHER INSTRUCTIONS CONTINUED

4. **Activity 1 - understanding current food production systems:** Students read about five different categories of agricultural production, and then evaluate, present, and discuss the sustainability of each agricultural system. If teachers wish to save class time, a homework option is described below in which students are assigned the reading for homework rather than completing it in class.

- Handout the "Graphic organizer 1: Comparing Food Production Systems" worksheet to the students, and review with them what an "optimal" food production system would look like. Compare the list on the worksheet to the criteria the students brainstormed with after the "Thought for Food" video.
- Ask the students to think about whether or not our "optimal" food production system might look different in different geographical areas. For example, how might the climate of a region impact the type of farming methods used there?
- As a class, read the following articles about small farms/traditional farming (Group 1): http://www.wildmadagascar.org/overview/loc/36-agriculture.html; https://casfs.ucsc.edu/about/publications/Teaching-Direct-Marketing/pdf%20downloads/Unit.1.pdf (pgs. 5-7)
- Calculating the sustainability scores: With student input, fill in the first column "Small/Traditional Farms" of the "Graphic organizer 1". Each criteria should be assigned a number as follows: 1 = high level of sustainability, 2 = medium level of sustainability, 3 = least sustainable. For this exercise, sustainability of a food production system means it both produces a high quantity of food while simultaneously maintaining the health of the environment. Add up the numbers in a column to obtain the overall sustainability score for a particular food production system. The lowest overall value will determine the most sustainable food production system.
- Break the students up into groups of 2-4. Assign each group (or let them choose) one of the four remaining agricultural methods to read about. Each student group should then read the article(s) associated with their specific food production system (see links below), and fill in the appropriate column of the "Graphic organizer 1". Some of their articles may provide information on other agricultural production systems, so they should fill in other areas of the chart if possible. Tell the students that the articles might not provide them answers to every criteria, they may need to infer a value from the text. Also, they should read all of the articles and annotate them before they choose a value for a particular criteria. Finally, be clear with the students that the articles that they are reading may be biased, depending on the source the information is coming from. Discuss with the students: "What is the value of reading potentially biased articles, and how do we remain objective while we are doing so?" (This question will hopefully generate discussion about how it is important be open to different ideas and perspectives. Staying objective will involve taking into consideration the source, cross-checking information, overcoming one's own bias, and referring to peer-reviewed scientific articles for further information.)
- The answers to the Graphic Organizer 1 table can be found in "Lesson 2 Teacher Key" (see Resources). However, there are not necessarily any "correct" answers to the graphic organizer. If a student can justify their values based on the reading, then it is "correct".
- Homework option: Instead of having students read their articles during class time, teachers can assign the article reading as homework, in addition to filling out the Graphic Organizer 1 for a particular food system. The small/traditional farming group 1 reading can also be assigned to a group instead of read by the whole class. The teacher can resume discussion of the chart with the class the following day.

Group reading articles:

Group 2: Native/Organic Farming
- http://organic-farming.farm/
- https://www.scientificamerican.com/article/organic-farming-yields-and-feeding-the-world-under-climate-change/
- http://www.cnn.com/2017/03/22/opinions/organic-farming-conversation/index.html

Group 3: Industrial/Commercial Farming
- http://www.sdsoybean.org/scoop-on-soybean-blog/a-visit-to-the-largest-soybean-farm-in-the-world/
- http://www.globalharvestinitiative.org/Documents/Motes%20-%20Modern%20Agriculture%20and%20Its%20Benefits.pdf (pgs. 12-16)
- http://psep.cce.cornell.edu/facts-slides-self/facts/mod-ag-grw85.aspx

Group 4: Hydroponics
- http://web.mit.edu/12.000/www/m2015/2015/hydro_agriculture.html
- https://www.maximumyield.com/hydroponics-pros-and-cons-of-hydroponic-gardening/2/3049
- https://www.theguardian.com/environment/2016/aug/14/world-largest-vertical-farm-newark-green-revolution

Group 5: Aquaponics
- https://cdn.shopify.com/s/files/1/0941/8606/files/Curriculum_Unit2_WG_9a283ab6-af9e-4f16-a89a-8effaf126f67.pdf?16617835315743887852
- https://www.researchgate.net/publication/303186885_Aquaponics_and_its_potential_for_food_security_in_Kenya
- https://www.nasa.gov/audience/foreducators/9-12/features/aquaponics.html

- Once all the groups have finished reading their articles and filling in their appropriate column, have each group present their findings to the class. All groups should complete the chart as the different agricultural systems are presented. They can present their information verbally, or they could create a poster.
- Discuss the following questions with the class, related to their findings from the table:
  1. Were there any categories that you had difficulty scoring for your particular system? This question will hopefully start a discussion about how there is a lot of diversity of farm types within each of these categories.
  2. Do you think the sustainability score is an accurate representation of the value of a certain production system? Why or why not? What else might you incorporate into a sustainability score? Some ideas that might surface include use of genetically-engineered seed, food quality, cost to the consumer, etc.
  3. What are some differences in the types of foods that each system produces? The scoring system doesn't evaluate the quality of the food produced, and this could be an important consideration. Organic food might be slightly more nutritious, and aquaponics is highly valuable in that it produces protein in addition to carbohydrates.
  4. Do any of the agricultural production methods have an optimal sustainability score? Is this production method in fact "ideal"? Why or why not? Aquaponics may come up with a perfect score, but the initial start-up cost might not be feasible in some cases.
  5. Can you think of geographical variables that might make one system more optimal than another, regardless of the sustainability score? For example, aquaponics would be a good fit for an arid environment because of its low water usage, but organic farming might be a better alternative in very poor, rural areas where funding is an issue and power outages occur.

TEACHER INSTRUCTIONS CONTINUED

5. **Activity 2 - designing a solution:** In this third part of the lesson, students use their knowledge of the different food production systems to propose how to produce enough food, sustainably and efficiently, for the same country they investigated in FS Lesson 1 (Haiti, North Korea, or Namibia).
- Students now re-form the three country groups they worked in during FS Lesson 1, and fill out questions 1 and 2 in the Lesson 2 section of the "Building Your Case" worksheet
- Encourage students to consider/remember the following as they design a solution for their country's food insecurity situation:
  - What are the country's limiting natural resources? Soil? Water?
  - Are there political or socio-demographic factors that influence the food security? How will those be surmounted in your solution?
  - How will food be transported to people who need it?
  - How will food be produced throughout the year, beyond the growing season if there is one?
  - Are there other climatic issues that need to be considered in your solution?
  - Would different food production systems work better for different parts of the country?
- Have the students present their solution to the rest of the class, either verbally or in poster form depending on available time.

6. **Formative Assessment/Exit Ticket:** In this final part of Lesson 2, the class finds similarities between the different food production systems by examining the environmental inputs necessary for all agricultural systems. The goal is to transition the students into "FS Lab 1: Creating an Efficient System" in which they will make their own aquaponic system.
   - Ask students to reflect about the following: we've talked about differences in agricultural production techniques. What do these systems have in common? Write their answers on the board as they brainstorm.
   - Have students quickly fill out (yes or no) the "Agricultural Necessities Chart" on the Lesson 2 Student Handout, and compare answers. It should be clear that all agricultural systems need certain biotic and abiotic factors, although hydroponics and aquaponics are slightly different in that they do not require soil and may not require sunlight if run on artificial lighting. Answers for this chart can be found in the "Lesson 2 Graphic Organizer & Chart Teacher Key" (see Resources).

EXTENSION ACTIVITY - READING SCIENTIFIC LITERATURE

This optional extension activity gives students the opportunity to practice reading scientific literature and making claims based on data. This activity can be assigned as homework after Lesson 2 or can be a practice activity as students prepare for Free Response Questions (FRQs) in AP courses.

- Read the following scientific paper and compare the sustainability of three apple farming systems: http://www.nature.com/nature/journal/v410/n6831/abs/410926a0.html
- Read the following scientific review of the need for sustainability in addressing food insecurity: https://www.nature.com/nature/journal/v418/n6898/pdf/nature01014.pdf

FURTHER BACKGROUND

Due to the student readings for this lesson being based on internet sources, some may expire. Below are additional links for each agricultural production system. In addition, several overview sources on sustainability and agricultural systems are provided.

Overview articles/books: sustainability and agricultural systems:

- https://www.nature.com/nature/journal/v418/n6898/pdf/nature01014.pdf
- http://www.agcensus.usda.gov
- http://www.fao.org/agriculture-consumer-protection-department/en/
- http://www.worldbank.org/en/topic/agriculture
- Book: "The Omnivore's Dilemma", Michael Pollan

Small/Traditional Farms:

- http://www.history.com/news/hungry-history/thomas-jefferson-americas-pioneering-gourmand
- https://www.agcensus.usda.gov/Publications/2007/Online_Highlights/Fact_Sheets/Farm_Numbers/small_farm.pdf

Organic agriculture overview:

- http://kerrcenter.com/wp-content/uploads/2014/08/organic-philosophy-report.pdf
- http://www.sare.org/Learning-Center/Bulletins/Transitioning-to-Organic-Production/Text-Version/What-is-Organic-Farming
- https://www.usda.gov/media/blog/2011/04/26/organic-farm-provides-model-new-mexico

Commercial agriculture overview:

- https://www.nature.org/ourinitiatives/regions/southamerica/brazil/explore/brazil-china-soybean-trade.pdf
- http://www.economist.com/technology-quarterly/2016-06-09/factory-fresh

Hydroponics:

- http://www.simplyhydro.com/whatis.htm
- http://www.powerhousehydroponics.com/4-commercial-vertical-farms-worth-attention/
- http://www.economist.com/node/17647627

Aquaponics:

- http://www.developonics.com/wp-content/uploads/2017/04/Aquaponics-in-Namibia-WUR.pdf
- http://ase.tufts.edu/water/pdf/Practicum_Andros_FinalReprt_2015.pdf
- http://freshfarmct.org/about/

RESOURCES

- SEE website: isbscience.org
  - Food Security Vocabulary PowerPoint
  - 3 Pillars PowerPoint
- Student "Thought for Food" video guide handout
- Teacher "Thought for Food" video teacher key
- Lesson 2 Student Handout - Graphic Organizer 1 & Chart
- Lesson 2 Graphic Organizer & Chart Teacher Key
- "Building Your Case" worksheet
- "Thought for Food" documentary video: https://drive.google.com/openid=1qk7CqP5uuzgiewg9OvVEs9dJz_SzVzJC

RESOURCES: STUDENT HANDOUT - THOUGHT FOR FOOD VIDEO GUIDE

1. What is the main idea behind the video?

2. As a global society we used to only have to feed 2 people off of a hectare of land, we now need to feed _____ people.
3. Food for thought runs a challenge each year to generate ideas, over 100 teams entered _____ were chosen as finalists.

Team Agrilution-The Netherlands

4. What is vertical farming?

5. How will it help with securing food?

6. How are they also helping with water conservation?

7. Name two benefits of using a greenhouse to grow food.

8. Why is the team using both red and blue lights to grow their food?

Team Oasis- Kenya

9. Women in Sub Saharan Africa spend more than _____ billion hours collecting water each year.
10. Of all the water on Earth, _____% is in the seas, leaving only _____% of fresh water, of which only about _____% is available.
11. What is team oasis' idea?

Team Henlight- California

12. What aspect of food production is team henlight trying to increase?

13. How is egg production in chickens and the time of year (season) related?

14. How will the henlight help to increase production?

Team Five Loaves- Nebraska

15. What issue is team five loaves focusing on?

16. What is their plan to get it done?

17. What is the economic benefit to the restaurants involved?

Team Ingenerovictus- India

18. What issue are they focusing on?

19. What products will their plan generate?

20. If you were one of the judges in the competition which project would you choose to win? Why? (Justify your answer)

21. The winner of the global summit is _____!

If you are interested in generating a team to compete in the next Thought for Food challenge, go to http://www.tffchallenge.com/challenge for information.

LESSON 2: CRITICALLY EVALUATING FOOD PRODUCTION TECHNIQUES

RESOURCES: TEACHER - THOUGHT FOR FOOD VIDEO TEACHER KEY

1. What is the main idea behind the video? To highlight the growing concern over our lack of food security. We will need to feed 9 billion people by 2050.
2. As a global society we used to only have to feed 2 people off of a hectare of land, we now need to feed _____5____ people.
3. Food for thought runs a challenge each year to generate ideas, over 100 teams entered _____5_____ were chosen as finalists.

Team Agrilution-The Netherlands

4. What is vertical farming? Farming using the vertical space, as a way of cutting down on the amount of land being used to produce the same amount of goods. A lot of times, this is done using greenhouses. Farm in stacks.
5. How will it help with securing food? Able to use less land, while still producing as much food.
6. How are they also helping with water conservation? Being able to minimize the amount of water being used, by recycling the water.
7. Name two benefits of using a greenhouse to grow food. Able to control light, CO2, nutrients, water, humidity. You also do not have to worry about pests, other animals, or the weather as much.
8. Why is the team using both red and blue lights to grow their food? These are the two wavelengths of light most absorbed by plants. Then plants reflect back green wavelengths as a part of the visible light spectrum. Using the red and blue lights, optimizes the light energy being given to the plants or a higher yield in crops.

Team Oasis- Kenya

9. Women in Sub Saharan Africa spend more than ___40___ billion hours collecting water each year.
10. Of all the water on Earth, __97__% is in the seas, leaving only ___3__% of fresh water, of which only about ___~1__% is available.
11. What is team oasis' idea? Being able to build structures, that people can live in, that will also be used to turn salt/ rain water into drinkable water using evaporation and condensation techniques.

Team Henlight- California

12. What aspect of food production is team henlight trying to increase? Eggs
13. How is egg production in chickens and the time of year (season) related? Chickens produce more eggs during the summer time, when the hours of light in the day is more.
14. How will the henlight help to increase production? By using solar power to supply energy to the device during the day, when there is a lack of light, the device will power on. This will help trick the light sensors in the brain of the chickens that the day is actually longer, so they will continue to produce eggs.

Team Five Loaves- Nebraska

15. What issue is team five loaves focusing on? Trying to highlight the fact that some people get too much to eat, while others are starving. Focusing on balancing out calories for each side.
16. What is their plan to get it done? Talk to local restaurants about a featured, healthy meal. When someone orders that meal, the restaurant donates 25 cents to Five Loaves, they will in turn use the money to help support an organization that globally is focused on food security.
17. What is the economic benefit to the restaurants involved? Additional advertising. They are also highlighted for their healthy options.

Team Ingenerovictus- India

18. What issue are they focusing on? The overwhelming amount of food waste produced, especially in India. The are working with local restaurants to collect their food waste.
19. What products will their plan generate? From the food waste they will generate biofuel and manure.
20. If you were one of the judges in the competition which project would you choose to win? Why? (Justify your answer)
21. The winner of the global summit is _____henlight_____!

If you are interested in generating a team to compete in the next Thought for Food challenge, go to http://www.tffchallenge.com/challenge for information.

RESOURCES: STUDENT HANDOUT - GRAPHIC ORGANIZER 1 & AGRICULTURAL NECESSITIES CHART

GRAPHIC ORGANIZER 1: COMPARING FOOD PRODUCTION SYSTEMS

Directions: Read through the articles assigned to your group. Using the information from the articles, as well as what you already know about your agricultural production system, fill in the following chart with your partner. For each criteria (e.g. water use, nutrient addition), you need to assign your food production technique a value of 1, 2, or 3: 1 = most sustainable, 2 = medium level of sustainability, 3 = least sustainable. A high sustainability score means high food productivity while maintaining the health of the environment. The articles may not provide you with all the information you need to fill out the chart, in which case you will need to think about how your food production technique works overall and infer a value. We will calculate the sustainability scores as a class.

	SMALL/ TRADITIONAL FARMS	NATIVE/ ORGANIC FARMING	INDUSTRIAL/ COMMERCIAL FARMING	HYDROPONICS	AQUAPONICS	OPTIMAL SCORE
WATER USE						
NUTRIENT ADDITION						
FOOD PRODUCTION						
ARABLE LAND/ SPACE REQUIREMENT						
OVERALL COST						
ENVIRONMENTAL IMPACT						
ENERGY USE						
SUSTAINABILITY SCORE						
OVERALL SYSTEM DESCRIPTION						
ADDITIONAL SYSTEM NOTES						

AGRICULTURAL NECESSITIES CHART

Directions: Write "Y" or "N" in the boxes below to indicate whether or not an agricultural system requires a particular biotic or abiotic factor to be productive.

	NUTRIENTS	WATER	SOIL	NITROGEN-FIXING BATERIA	SUNLIGHT	CARBON DIOXIDE
SMALL/TRADITIONAL FARMS						
NATIVE/ORGANIC FARMING						
INDUSTRIAL/ COMMERCIAL FARMING						
HYDROPONICS						
AQUAPONICS						

LESSON 2: CRITICALLY EVALUATING FOOD PRODUCTION TECHNIQUES

RESOURCES: GRAPHIC ORGANIZER AND AGRICULTURAL NECESSITIES CHART TEACHER KEY

GRAPHIC ORGANIZER 1: COMPARING FOOD PRODUCTION SYSTEMS

Directions: Read through the articles assigned to your group. Using the information from the articles, as well as what you already know about your agricultural production system, fill in the following chart with your partner. For each criteria (e.g. water use, nutrient addition), you need to assign your food production technique a value of 1, 2, or 3: 1 = most sustainable, 2 = medium level of sustainability, 3 = least sustainable. A high sustainability score means high food productivity while maintaining the health of the environment. The articles may not provide you with all the information you need to fill out the chart, in which case you will need to think about how your food production technique works overall and infer a value. We will calculate the sustainability scores as a class. (For the teacher: **black lettering** = discuss as a class; red lettering = students fill these in while reading their articles)

	SMALL/ TRADITIONAL FARMS	NATIVE/ORGANIC FARMING	INDUSTRIAL/COMMERCIAL FARMING	HYDROPONICS	AQUAPONICS	OPTIMAL SCORE
WATER USE	2	2	3	1	1	1
NUTRIENT ADDITION	1 - 3	1	3	2	1	1
FOOD PRODUCTION	2 - 3	2 - 3	1	1	1	1
ARABLE LAND/ SPACE REQUIREMENT	2	2	3	1	1	1
OVERALL COST	1 - 2	2	2 - 3	2	2	1
ENVIRONMENTAL IMPACT	2 - 3	1	3	1	1	1
ENERGY USE	1 - 2	1	3	3	2	1
SUSTAINABILITY SCORE	11-17	11 - 12	18-19	11	9	7
OVERALL SYSTEM DESCRIPTION	Huge diversity of farms, ranging from slash-and-burn agriculture in developing countries to farms that earn <$250,000 profit in the US.	Food is grown in an environmentally sustainable way using techniques such as crop rotation, composting, and integrated pest management.	Large-scale farming that focuses on producing large amounts of food using synthetic fertilizers, pesticides, machinery, and often genetic engineering	Plants are grown directly in water and are provided nutrients directly, rather than absorbing them from soil.	Combines aquaculture with hydroponics by using the waste of aquatic organisms to fertilize plants.	
ADDITIONAL SYSTEM NOTES						

AGRICULTURAL NECESSITIES CHART

Directions: Write "Y" or "N" in the boxes below to indicate whether or not an agricultural system requires a particular biotic or abiotic factor to be productive.

	NUTRIENTS	WATER	SOIL	NITROGEN-FIXING BATERIA	SUNLIGHT	CARBON DIOXIDE
SMALL/TRADITIONAL FARMS	Y	Y	Y	Y	Y	Y
NATIVE/ORGANIC FARMING	Y	Y	Y	Y	Y	Y
INDUSTRIAL/COMMERCIAL FARMING	Y	Y	Y	Y	Y	Y
HYDROPONICS	Y	Y	N	Y	Y/N	Y
AQUAPONICS	Y	Y	N	Y	Y/N	Y

PROJECT FEED 1010

ISB Systems Education Experiences

LESSON 3: WHO CARES? STAKEHOLDERS!

THE BIGGER PICTURE

Stakeholders are a vital part of the food security system. It is important for students to realize that to solve the global issue of food insecurity, all of the stakeholders' voices must be represented. In a system, there are often trade-offs to being able to make something work. They will have an impact on the system and other stakeholders, based on the choices they make and the resources they use. In this activity, each student group of 2-3 (depending on class size) will be assigned the role of a stakeholder and will receive a stakeholder information card along with guiding questions that will help them prepare a 2-3 minute poster presentation to the rest of the class on their stakeholder's position on the food security crisis. Each student will also be given a blank stakeholder table to fill in the information being presented by their classmates. This activity will be followed by lesson FS4 where students will build a causal loop diagram of the network created by the stakeholders involved in the food security crisis.

OBJECTIVES

What students learn

Stakeholders are people, groups, or organizations with a vested interest in an issue. Students recognize the influence of stakeholders in decision making and the challenges of coming to a consensus. There are many stakeholders involved in the food security crisis.

What students do

Students are assigned the role of a stakeholder. After examining the stakeholder's information, students introduce themselves through presentations and generate a response to a critical question: will an increase in food production alone solve the global food crisis.

TIME

50 minutes - 1 class period

STANDARDS

- NGSS PE: HS- ESS3.1; DCI: ESS3. A; SEP: Constructing Explanations and Designing Solutions; CC: Cause and Effect
- NGSS PE: HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS
- CCSS ELA-LITERACY.RI.11-12.1 Key ideas and details in text

PREREQUISITES

There are no course prerequisites. However, there are assumptions: 1) students have already completed the Cell Phone Network activity and/or know what a network is, 2) students have been introduced to the concept of food security through lesson one, and 3) be familiar with the Stakeholder Resource Guide.

BEFORE CLASS

Students should have been given the Stakeholder Reference Guide to look over and read. Teacher needs to provide a copy of the Stakeholder Table (1 per student), Stakeholder Cards (1 per group), and the Stakeholder Guiding Questions (1 per student). One ball of yarn is required if completing the optional "Yarn Toss" activity (step 4). All of the *Modeling Sustainable Food Systems* resources are on the SEE website: isbscience.org.

TEACHER INSTRUCTIONS

1. Start by reviewing what the students learned in Lesson FS1 about the three pillars of food security, then review how they looked at different farming techniques in Lesson FS2.
2. Explain that the objective of this lesson is to focus on the stakeholders involved in solving the issue of food insecurity.
3. In the class period before the lesson, make sure that the students are given the Stakeholder Reference Guide to review as homework. Ask if there are any of the terms that they either do not understand or have a question about.
4. **Yarn Toss: optional interactive vocabulary activity (15 minutes).** This activity provides a more interactive, stimulating approach to learning new vocabulary. Students stand in a large circle around the room. One student holds the end of the ball of yarn and calls out one of the vocabulary words from the Stakeholder Reference Guide. They then explain the definition of that word. While holding the end of the yarn, they throw the ball across the circle to another student. The new student must select a new word from the vocabulary list and explain how the new word is related (by any means) to the previous vocabulary word. This process continues until you've used all words on the vocabulary list. To wrap up, ask students what they notice about the pattern they've created with their yarn. What does that represent? Discuss how these words are all part of a larger network, or system.
5. Ask the class how they would define the term stakeholder. This could be a warm-up question either they respond to verbally or in their notebook. Get responses from 2 or 3 students. Explain that Merriam-Webster's dictionary describes a stakeholder as "one that has a stake in an enterprise, or someone who is involved in or affected by a course of action".
6. Explain to the students that in small groups they are going to investigate some of the stakeholders that are involved with food insecurity. Each stakeholder has a unique perspective on how the global food crisis affects them and how they think it should be addressed.
7. Group students into 2 or 3 individuals (depending on class size). Pass out the Stakeholder Cards (1 card per group). This will assign a stakeholder role to each group. For smaller classes, you can pass out 2-3 cards for each group; however, they will need more time to complete the activity.
8. Pass out Stakeholder Guiding Questions - one copy to each student, or one per group. Students can use those questions to help them decide what information should be included in their Stakeholder Table.

TEACHER INSTRUCTIONS CONTINUED

9. Share with students the Important Organizations listed in "Resources" section of the teacher instructions so they understand the organizations that are involved with the stakeholders.
10. Handout one copy of the Stakeholder Table per student. Students use this table to collect information about their stakeholder using the following resources: the Stakeholder Guiding Questions document, Stakeholder References guide and their Stakeholder Card.
11. **Following their research, students will prepare a 2-3 minute presentation** on their stakeholder to the rest of the class. Presentation ideas: students can present their information verbally to the rest of the class or in a poster walk format, focusing on answering the guiding questions for their stakeholder. They can also present the information visually using one of the following options:
    - Option 1: Powerpoint presentation - focus on including pictures to represent the information pertinent to their stakeholder.
    - Option 2: Poster presentation - other than the stakeholder name, only pictures are allowed to represent the information about their role. These can then be hung up around the classroom as a reference for future lessons in this unit.
    - Option 3: If a class is very small, students can receive more than one stakeholder. One option is to group the stakeholders together based on similar roles (Ex. representatives of developed country farmers with small farmers in developing countries). Students can present their stakeholders by creating a poster to compare/contrast the two stakeholders. Similar to option 2, the posters should be used as a visual to represent the two stakeholders with as few words as possible. Students can put the name of each stakeholder at the top of their poster, then create a Venn Diagram to compare/contrast the two stakeholders.

    The final part of the presentation should include the position the stakeholder takes on answer the question from the Stakeholder Table, "Can we simply expand the current food production system as it is now to meet needs of 9 billion people by 2050/justify position?". Visit the resources tab in Lesson 3 at isbscience.org to see examples of student work.
12. Each student will complete their Stakeholder Table during the other stakeholder presentations. Once all presentations are complete, their table will also be complete with information about all stakeholders.
13. **Building your case worksheet:** Students now re-form the three country groups they worked in during the previous food security lessons, and fill out questions 1 and 2 in the Lesson 3 section of the "Building Your Case" worksheet. The goal of this activity is to continue to build their case for the summative assessment where they are participating in a UN summit.
14. **Wrap-up the lesson with an exit ticket**, which can either be done on a separate slip of paper or a reflection in their notebook.
    - Why is it important to consider stakeholders when generating a plan?
    - After hearing about the other stakeholders, was there a particular stakeholder that had more of an impact on global food security?

MODIFICATIONS

- The activity is designed for 2 students per group to encourage deep engagement and student accountability. If your group is smaller, these are the stakeholders you may delete or choose to combine. Some options are combining developing country fishermen and farmers, combining world policy makers and developed country government, combining energy and transportation systems
- If you have smaller classes and are combining stakeholders, an optional presentation idea is to have the students create a poster with a Venn diagram, focusing on the similarities and differences between their assigned stakeholders and each stakeholder's position.

RESOURCES

- SEE website: isbscience.org
    - Food Security Vocabulary PowerPoint
    - 3 Pillars PowerPoint
    - Student poster examples
- Stakeholder Reference Guide
- Stakeholder Guiding Questions
- Stakeholder Table
- Stakeholder Cards
- "Building Your Case" worksheet

Important Organizations

- World Health Organization (WHO): WHO is the directing and coordinating authority for health within the United Nations system. It is responsible for providing leadership on global health matters, shaping the health research agenda, setting norms and standards, communicating evidence-based policy options, providing technical support to countries and monitoring and assessing health trends. (http://www.who.int/about/en/)

- World Bank: The World Bank is a United Nations international financial institution that provides loans to developing countries for capital programs. The World Bank is a component of the World Bank Group, and a member of the United Nations Development Group. (http://www.worldbank.org)

- World Trade Organization: The World Trade Organization (WTO) is the only global international organization dealing with the rules of trade between nations. At its heart are the WTO agreements, negotiated and signed by the bulk of the world's trading nations and ratified in their parliaments. The goal is to help producers of goods and services, exporters, and importers conduct their business. (http://www.wto.org/english/thewto_e/whatis_e/whatis_e.htm)

- United Nations: The United Nations is an international organization founded in 1945 after the Second World War by 51 countries committed to maintaining international peace and security, developing friendly relations among nations and promoting social progress, better living standards and human rights. (http://www.un.org/en/aboutun/index.shtml)

RESOURCES: STUDENT HANDOUT -STAKEHOLDER REFERENCE GUIDE

Vocabulary

subsistence farming: typically a small-scale farming operation in which farmers focus on growing enough food to feed themselves and their families.

malnutrition: lack of proper nutrition, caused by not having enough to eat, not eating enough of the right foods, or being unable to use the food that one does eat.

infrastructure: the basic physical and organizational structures and facilities (e.g., buildings, roads, and power supplies) needed for the operation of a society or enterprise.

urbanization: the increasing number of people that live in urban areas. It predominantly results in the physical growth of urban areas, be it horizontal or vertical. The United Nations projected that half of the world's population would live in urban areas at the end of 2008.

monoculture: the agricultural practice of producing or growing a single crop or plant species over a wide area and for a large number of consecutive years

diversity: the condition of having or being composed of differing elements; variety

pathogens: a bacterium, virus, or other microorganism that has the ability to cause disease.

affluent: (especially of a group or area) having a great deal of money; wealthy.

food insecurity: the state of being without reliable access to a sufficient quantity of affordable, nutritious food.

inflation: a general increase in prices and fall in the purchasing value of money.

subsidies: a sum of money granted by the government or a public body to assist an industry or business so that the price of a commodity or service may remain low or competitive.

hygiene: conditions or practices conducive to maintaining health and preventing disease, especially through cleanliness.

agricultural treadmill: Because most farmers specialize in production of commodities such as feed corn or soybeans, which cannot be differentiated in the marketplace (i.e., Farmer John cannot claim that his feed corn is superior to Farmer Jane's, because for most intents and purposes, the corn is identical), they must take whatever the market price is when they choose to sell their crops. Because the price of grain is the same for all farmers, the farmers who earn profits are those who aggressively adopt new technologies that reduce production costs and boost yields relative to other farmers. While these "early adopters" profit from the use of new technology, once a given yield-enhancing technology is widely used, the resulting increases in supply lowers prices for all farmers.

lobbying: seeking to influence (a politician or public official) on an issue.
transgenic: of, relating to, or denoting an organism that contains genetic material into which DNA from an unrelated organism has been artificially introduced.

commodity: a raw material or primary agricultural product that can be bought and sold, such as copper or coffee.

tariffs: A tariff is either a tax on imports or exports, or a list of prices for such things as rail service, bus routes, and electrical usage.

speculation: the forming of a theory or conjecture without firm evidence. To place money into a stock on the belief that the value will rise rapidly.

biofuel: a fuel derived directly from living matter.

aquaculture: the rearing of aquatic animals or the cultivation of aquatic plants for food.

greenhouse gas: a gas that contributes to the greenhouse effect by absorbing infrared radiation, e.g., carbon dioxide and chlorofluorocarbons.

nonrenewable resource: A resource of economic value that cannot be readily replaced by natural means on a level equal to its consumption. Most fossil fuels, such as oil, natural gas and coal are considered nonrenewable resources in that their use is not sustainable because their formation takes billions of years.

RESOURCES: STUDENT HANDOUT -STAKEHOLDER REFERENCE GUIDE

Vocabulary Continued

renewable resource: A renewable resource is a natural resource which can replenish with the passage of time, either through biological reproduction or other naturally recurring processes. Renewable resources are a part of Earth's natural environment and the largest components of its ecosphere.

confounding: mix up (something) with something else so that the individual elements become difficult to distinguish.

sustainable agriculture: the act of farming using principles of ecology, the study of relationships between organisms and their environment. Farming using non ecological damaging practices.

agribusiness: the business of agricultural production. It includes agrichemicals, breeding, crop production (farming and contract farming), distribution, farm machinery, processing, and seed supply, as well as marketing and retail sales.

microbiology: is the study of microscopic organisms, either unicellular (single cell), multicellular (cell colony), or acellular (lacking cells).

zoonoses: diseases that are naturally transmitted from vertebrate animals to humans and vice-versa.

conglomerate: a number of different things or parts, such as businesses, that are grouped together to form a whole but remain distinct entities.

lethal: sufficient to cause death.

humanitarian: concerned with or seeking to promote human welfare.

desalinate: remove salt from (seawater).

conservation buffers: small areas or strips of land in permanent vegetation, designed to slow water runoff, provide shelter and stabilize riparian areas.

biodynamic: a whole farm approach that seeks to manage the soils, crops, and animals on a farm in such a way that the enterprises on a farm strengthen and support each other.

holistic: characterized by comprehension of the parts of something as intimately interconnected and explicable only by reference to the whole.

mutually reinforcing: A situation in which two parties work together, supporting the interests of each other.

dietary staples: Most staple plant foods are derived either from cereals such as wheat, barley, rye, maize, or rice, or starchy tubers or root vegetables such as potatoes, yams, taro, and cassava. The definition of a dietary staple varies depending on what part of the world you are referencing.

aquifer: a body of permeable rock that can contain or transmit groundwater.

tributaries: a river or stream flowing into a larger river or lake.

degradation: to be broken down or to deteriorate chemically.

sedimentation: Sedimentation is the tendency for particles in suspension to settle out of fluid, and come to rest against a barrier, such as the bottom of a container. This is due to their motion through the fluid in response to the forces acting on them, for example, gravity. Sedimentation happens as water erodes soils, carries the soil particles down the river, and then the particles build up against a barrier in the river.

ecosystem: a biological community of interacting organisms and their physical environment.

node: each part of the system

edge: links nodes together and defines relationship between the nodes and direction of communication between nodes

tipping node: a node that is vital to the system, and without it, the system would collapse

LESSON 3: WHO CARES? STAKEHOLDERS!

RESOURCES: STUDENT HANDOUT -STAKEHOLDER GUIDING QUESTIONS

As you look over your stakeholder cards and prepare to share your information with the rest of the class, be sure you understand the following information so you can be the expert on your stakeholder.

1. What is the name of your stakeholder group?

2. Why is your group considered to be a stakeholder? What is your role in the food security crisis?

3. What policy/policies does/do your group want to see in place with food security?

4. Why would these policies benefit you?

5. What do you predict will happen to your group if these policies are not enacted or put into place?

6. How essential is your group's role in the food security system? Are you a tipping point node?

7. Who do you think you most need to talk to or hear from to define your group's "place" in the food security system?

8. What nodes (stakeholders) do you think are most closely related to you? Why do you think this?

9. What should others know and understand about your group?

LESSON 3: WHO CARES? STAKEHOLDERS!

RESOURCES: STUDENT HANDOUT -STAKEHOLDER TABLE

STAKEHOLDER	KEY ISSUES IMPORTANT TO STAKEHOLDER	POSITION AND JUSTIFICATION STAKEHOLDER TAKES ON THE QUESTION: "Can we simply expand the current food production system as it is now to meet needs of 9 billion people by 2050?"
DEVELOPING COUNTRY ECONOMY AND GOVERNMENT		
REPRESENTATIVES OF A DEVELOPED COUNTRY ECONOMY		
REPRESENTATIVES FROM THE WORLD HEALTH ORGANIZATION		
WORLD POLICY MAKERS		
URBAN CITIZENS IN DEVELOPED COUNTRIES		
REPRESENTATIVES OF FOOD TRANSPORT COMPANIES		
REPRESENTATIVES OF AGRICULTURAL SUPPLY COMPANIES		

LESSON 3: WHO CARES? STAKEHOLDERS!

RESOURCES: STUDENT HANDOUT -STAKEHOLDER TABLE

STAKEHOLDER	KEY ISSUES IMPORTANT TO STAKEHOLDER	POSITION AND JUSTIFICATION STAKEHOLDER TAKES ON THE QUESTION: "Can we simply expand the current food production system as it is now to meet needs of 9 billion people by 2050?"
REPRESENTATIVES OF ENERGY COMPANIES		
FISHERMEN IN DEVELOPED COUNTRIES		
THE ENVIRONMENT		
REPRESENTATIVES OF EARTH'S WATER SUPPLY		
SMALL FARMERS IN DEVELOPING COUNTRIES		
REPRESENTATIVES OF DEVELOPED COUNTRY FARMERS		
FISHERMEN IN DEVELOPING COUNTRIES		
DEVELOPED COUNTRY CITIZENS		

LESSON 4: FOOD SECURITY AS A SYSTEM

THE BIGGER PICTURE

The goal of this lesson is to encourage students to look at the topic of food security using a systems approach, and to evaluate the stability of our global food production by assessing the interactions within the system. Students will review the definition of a system and discuss how approaching a problem or issue by modeling it as a system can lead to both improved understanding and more effective problem-solving. The lesson includes an overview of different methods used to visually represent systems-level problems, and students practice using these models to illustrate food security. Students will ultimately apply their knowledge of the concept of food security and the stakeholders involved to create a large causal loop diagram that helps them visualize interactions within the system, feedback loops, and tipping points. This activity will help students evaluate the sustainability of our food supply and the vulnerability of particular groups to food insecurity.

OBJECTIVES

What students learn

Students learn the 14 habits of a systems thinker and the 6 steps used to analyze systems, along with strategies for illustrating systems. They identify interactions between food security system parts as well as the "tipping points" which lead to irreversible change.

What students do

Students relate systems thinking habits to everyday situations, use a variety of diagrams to visualize systems, work collaboratively to create a large causal loop diagram of food security, and evaluate the stability of our food production system by assessing interactions, feedback loops, and tipping points.

TIME

50 minutes - 1 class period

STANDARDS

- NGSS PE HS-LS1-3; DCI: LS1.A; SEP: Planning and Carrying Out Investigations; CC: S&C
- NGSS PE HS-LS2-7; DCI: LS2.C & LS4.D; SEP: CEDS; CC: S&C
- NGSS PE HS-LS2-8; DCI: LS2.D; SEP: Engaging in Argument from Evidence; CC: Cause and Effect
- NGSS PE HS-ESS3-1; DCI: ESSE.A; SEP: CEDS; CC: C&E
- NGSS HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

PREREQUISITES

Students should have completed the cell phone network activity (Introduction to Systems) and have a working definition of a network. Students should have also participated in Lessons FS1 and FS3, therefore they should be familiar with both the concept of food security and the different stakeholders involved in the food production system.

BEFORE CLASS

Gather materials (see "Resources" section): Food Security Vocabulary PowerPoint, "Is It a System?" worksheet (one copy per student) and teacher notes, "Habits of a Systems Thinker" worksheet (teacher copy and one copy cut up to distribute pictures to students), "S.T.O.P." handout (one copy per student), and the "Example Food Security Network Diagram" image. You will also need a large piece of butcher paper or poster board for the class causal loop diagram, along with multi-colored markers. Read through the "Teacher Notes" of the "Is It a System?" activity. The students will also need their "Building Your Case" worksheet.All of the *Modeling Sustainable Food Systems* resources are on the SEE website: isbscience.org.

TEACHER INSTRUCTIONS

1. **Warm-Up:** Students come up with a definition for a nutrient cycle, which will get them thinking about cycles and interconnections between different parts of an ecosystem. This serves as a transition between the optional "Creating an Efficient System" lab and the idea of food security as a system.
   - Food Security Vocabulary PowerPoint: Show the Food Security Vocabulary PowerPoint for Lesson 4. Have students brainstorm what a "nutrient cycle" is, and list examples of different nutrient cycles. Tell the students that they will revisit the idea of nutrient cycles at the end of the lesson, but will be able to look at them with a new perspective.
     Nutrient cycle definition: "the cyclic conversion of nutrients from one form to another within biological communities"
     Nutrient cycle examples: carbon cycle, nitrogen cycle, phosphorus cycle
   - Tell the students that the purpose of this lesson is to evaluate the issue of food security using a systems approach. So far they have learned about the global food crisis, the different agricultural production systems, and the stakeholders involved. In this lesson, they will be thinking about how the differents nodes of the food security system interact with and influence each other.
2. **Formative Assessment - Defining a System:** Students identify different types of systems on a worksheet, and discuss the meaning of and dynamics within a system.
   - Hand out the student worksheet, "Is It A System?", and have students work in partners to determine which items are systems and which ones are not. Ask the students to justify their answers on the worksheet.
   - Worksheet answer: any answer is potentially correct, as long as students can provide a valid justification for how it represents a system. For example, most students would not think a pile of sand is a system because it's composed of one component. However, other students might argue that if you remove one grain, it impacts the overall structure and properties of the rest of the pile.

TEACHER INSTRUCTIONS CONTINUED

- Read out or write the following on the board: system definition: "a collection of things (including processes) that have some influence on one another and the whole...To be considered a system, the components must interact with or influence each other in some way...Systems have boundaries, components, resources, flow (input and output), and feedback" ("Is it a System?", NSTA 2009. Different types of systems include manufactured objects, life-forms, combinations of living and nonliving things, physical bodies, processes, or quantitative relationships. **Discuss the following with the students:**
  1. What is the goal of modeling a system rather than studying its individual parts?
  - The overall system has properties that are different from its individual parts. Understanding the system can help to explain why things happen, and can help predict future changes.
  2. Why is feedback important in systems relationships? Can you think of examples of feedback loops in nature?
  - The stability of a system can be greater when it includes appropriate feedback mechanisms. Feedback can encourage a certain pathway in a system, discourage it, or help maintain stability.
  - Examples: blood sugar levels in the human body (negative), body temperature regulation (negative), glacial melt and climate change (positive), gene regulatory mechanisms (positive or negative)
  3. Can you come up with examples of systems that have the word "system" in them? How about examples of systems that don't include the word "system"?
  - Examples: ecosystem, solar system, circulatory system, nitrogen cycle, global climate, a car
  4. How can the idea of systems be applied to the our food production?
  - The food production system has many different interacting parts and relationships between them (e.g. the farm, transport systems, fertilizer production, grocery stores, consumer households), the overall goal of which is to produce food for the consumer to eat. For the food to be produced, all nodes in the system need to be functioning well.

3. **Activity 1 - How to think about and model systems-level problems:** Students learn and discuss the habits of a systems thinker and five different approaches for visually modeling systems.
   - Tell students that different thinking strategies or habits foster problem-solving, questioning, and understanding when approaching a complex issue such as food insecurity.
   - Hand out a "Habits of a Systems Thinker" worksheet picture to each student, and ask the students to take a minute to think about how the picture represents an effective "habit of a systems thinker". The student should also come up with an example of how to apply the habit from their picture to a situation in daily life. Have the students share their thoughts with the rest of the class. Students could also work in pairs on one card, depending on the class size.
   - Hand out a copy of the "S.T.O.P Coffee Crutch Story" handout ("Habits of a Systems Thinker" pictures on the back) to each student. Tell the students that when we are analyzing a systems-level problem/issue, it is helpful to follow the 6 steps of systems analysis, as described on the worksheet.
   - Tell the students that there are different visual representations that we can use to model systems problems, and these include: Iceberg Model, Stock/Flow Diagram, Behavior Over Time Graph, Connection Circle, and Causal Loop Diagram (these models are demonstrated on the "S.T.O.P Coffee Crutch Story" handout).
   - Have the students read through "The Coffee Crutch" story on the "S.T.O.P Coffee Crutch Story" handout. Then, have them study the Iceberg Model. Discuss the following questions with the students:
     1. What does the tip of the iceberg represent?
     - Joe's fatigue - this event is the result of several interacting processes.
     2. What does the part of the iceberg underneath the sea surface represent?
     - The interacting causes of the ultimate result (fatigue) - these include Joe's assumptions and worldview ("Mental Models"), the structure of his day and his workplace ("Structure"), and his patterns of behavior ("Patterns").
     3. How is this problem like a treadmill? (refer to the graphic on the S.T.O.P. worksheet)
     - Joe's patterns of behavior and the structure of the system in which he works accentuate his fatigue. It is a positive feedback loop whereby the more caffeine he drinks, the more tired he will feel, which will ultimately lead to him drinking more coffee.
     4. Can you think of any other potential factors that might play into Joe's caffeine habit, i.e. that we could list under the sea surface?
     5. How could we design an investigation to test one aspect of this Iceberg model using the Coffee Crutch story?
   - **Transition to Activity 2** by asking the students, "Can food security be viewed/modeled as a system? Why or why not?" Definitely! The different nodes of the system are highly interconnected, and the actions of one stakeholder or a disruption in the availability of a resource could greatly impact other nodes in the system.

4. **Activity 2 - Modeling Food Security as a System:** In small groups, students diagram the issue of food security using either the Stock/Flow Diagram or Connection Circle, and then create a large Causal Loop Diagram of food security as a class.
   - Break students up into small groups of 2-3, and have them choose either a Stock/Flow Diagram or a Connection Circle to model the issue of food security. The idea is for them to figure out the components of these two models on their own, and apply them to the issue of food security.
   - As a class, or in large groups of 8-10, students now come together to build a large Causal Loop Diagram of the issue of food security using butcher paper and multi-colored markers (an example is provided in the Resources section, "Example Food Security Network Diagram" image). The student groups or class can choose one representative to build the diagram as they brainstorm ideas, or everyone can be drawing the diagram together. Help students along by delivering the following prompts:
     1. What do you think the nodes of the causal loop diagram are?
     - These could include the different stakeholders, environmental factors (water, disease, soil, biodiversity), large-scale patterns (e.g. climate change) and a variety of other concepts and phenomena (e.g. technology).

TEACHER INSTRUCTIONS CONTINUED

2. How are the different nodes connected to one another?
3. Are there any interactions between nodes that are one-directional? Or is there feedback? Is this feedback part of a "Balancing Loop" (negative feedback loop), or a "Reinforcing Loop" (positive feedback loop)?
   - For example, poverty might lead to low-investment/high immediate return agricultural techniques such as slash and burn, which contribute to land degradation in the long-term. Land degradation in turn creates more poverty as people are unable to produce food. The interaction between poverty and land degradation is a "Reinforcing Loop".

- Once students have created a complex food security Causal Loop Diagram, **conclude the activity** by asking the students:
  1. Are there any nodes that are more influential than other nodes? Which ones, and why?
  2. Can you identify any "tipping point" nodes within the system? These are nodes that if removed, irreversible change will occur.
  3. Which nodes, if any, can be removed without impacting the system at all?
  4. Which stakeholders in the system are most vulnerable to changes in the system? Can you identify them from your diagram?
  5. Do you think food security is a stable system? Why or why not? What would contribute to greater stability?

5. **Building Your Case:** have the students complete the questions for this FS Lesson 4 on the "Building Your Case" worksheet. Here, they will apply the systems analysis tools that they have learned about in this lesson to modeling food security in their country.
6. **Exit Ticket:** Tell the students that to wrap up the lesson, we are revisiting the concept of nutrients cycles. However, this time, the goal is for them to think about a nutrient cycle using a systems approach, within an aquaponics system. Students should take 4-5 minutes to respond to the following prompt in their notebooks: "Draw and label a systems diagram that shows one of the nutrient cycles within an aquaponic system".

RESOURCES

- SEE website: isbscience.org
  - Food Security Vocabulary PowerPoint
  - Example food security network diagram
  - "Is It a System?" worksheet and teacher notes (Science Formative Assessment, Keeley 2009)
  - "Habits of a Systems Thinker" handout (Waters Foundation 2017)
  - "S.T.O.P. Coffee Crutch Story" handout
  - "Building Your Case" worksheet

LESSON 5: WHY DON'T WE JUST GROW MORE?

THE BIGGER PICTURE

In Lesson FS1, students were asked to respond to a formative assessment question: "Is the answer to the growing lack of food security in a growing population simply to grow more food?". Students will revisit their responses and will be using today's lesson to add to or modify their answer and justifications by exploring the issue of why solving the global food crisis by simply growing more food is not as easy in reality as it is on paper. In Lesson FS4, students started to visualize food security as a system. They will continue to explore the idea that when nodes are interacting in a system, modifying one node can have far reaching consequences for the entire system. In this lesson, students will focus on the stakeholders introduced in Lesson FS3, by analyzing an article and evaluating the impact that possible solutions to global food insecurity will have on stakeholders.

OBJECTIVES

What students learn

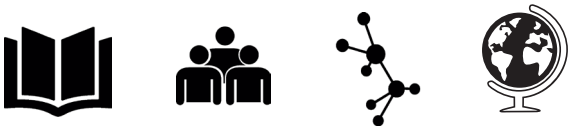
Students recognize that solving the global food security crisis is complex and that decisions made to address it will affect all stakeholders. Students also learn some network nodes have more influence than others.

What students do

Students work in groups to analyze The Great Balancing Act, a working paper from the World Resources Institute. In partners, students analyze the impact each stakeholder would have in each of the suggested scenarios and connect the concepts to the network.

TIME

50 minutes - 1 class period



STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-LS4-6; DCI: HS-LS4C & HS-LS4D; SEP: Using Mathematics and Computational Thinking; CC: C&E
- NGSS PE: HS-ESS2-5; DCI: HS-ESS2C; SEP: Developing and Using Models; CC: Energy and Matter
- NGSS PE: HS-ESS3-1; DCI: HS-ESS3A; SEP: CEDS; CC: C&E
- NGSS PE: HS-ESS3-4; DCI: HS-ESS3C; SEP: CEDS; CC: S&C & ETS
- NGSS PE: HS-ETS1-3; DCI: ETS1.B; SEP: Asking Questions and Defining Problems; CC: Influence of ETS
- NGSS HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS

PREREQUISITES

There are no prior course prerequisites; however, students should have completed the previous lessons in the FS module, as well as the cell phone network activity (Introduction to Systems).

BEFORE CLASS

Print out a copy of the "The Great Balancing Act" article for each student or allow students to access the link electronically. Print out a copy of the Balancing Act Article Chart Analysis Handout for each student. If using the optional reading guide handout, print out 1 copy per student along with 1 copy of the teacher guide to the handout. Students will also need their "Building Your Case" worksheet. Download the Food Securtity Vocabulary PowerPoint. All of the *Modeling Sustainable Food Systems* resources are on the SEE website: isbscience.org.

TEACHER INSTRUCTIONS

1. **Warm-Up:** Students come up with a definition for the words "ecosystem" and "nonrenewable resource". These vocabulary terms were included as they are one focal point discussed in the article students will be reading. One of the main objectives of the article is to examine how we can provide more food by 2050, while not increasing our impact on the environment. To maintain a balanced, healthy ecosystem, we must decrease our resource use and dependence on nonrenewable resources.

- Show the Food Security Vocabulary PowerPoint for Lesson 5. Have students brainstorm what an "ecosystem" is, and list examples of different ecosystems.
  - Ecosystem definition: the complex of a community of organisms and its environment functioning as an ecological unit.
  - Nonrenewable resource definition: any natural resource from the Earth that exists in limited supply and cannot be replaced if it is used up; also, any natural resource that cannot be replenished by natural means at the same rates that it is consumed.

2. **Critically Evaluating Solutions through Literature Review**

- Ask students to look at their answers to the wrap-up question in Lesson FS1, "is the answer to food insecurity simply growing more food?", and discuss at their table what their response was. Have them decide if they are satisfied with it and ask for volunteers to share out their answers. Let them know that we will continue to evaluate this question of why don't we just grow more food as we analyze an article today and the impact that the various stakeholders have on the problem.
- Place students in pairs to read the article "The Great Balancing Act". It is suggested that they are in the same pairs as they were for Lesson FS3 (Who Cares? Stakeholders!)
- Have students silently read pgs 1-9 making sure to look at the diagrams. There are three objectives the article is built around (page 9): a) the world needs to close the gap between what food is needed today and what will be needed by 2050, b) the world needs agriculture to contribute to inclusive economic and social development, and c) the world needs to reduce agriculture's impact on the environment and natural resources. Let students know that, as a class, we will be looking at the chart on pages 10-13. Instructions for reading and analyzing the chart can be found in the "Analysis Activity with Chart".

TEACHER INSTRUCTIONS CONTINUED

- As they are reading, students need to be underlining with a purpose as well as circling vocabulary words that are important, repeated and defined in the text. Ask students to use the margins of their articles to write a sentence or two summarizing what the author meant or any questions they have about the article. Optional: To reduce time needed to read the article or accommodate students with lower reading ability, teachers can break the text into smaller segments for the students and assign different groups to different sections of the article (jigsaw).
- Once students have read, have them discuss what they discovered with their reading partner. Ask them to begin to formulate an answer to the question, "Why can't we just grow more food?", by writing a few rough sentences that begin to explain their viewpoint based on what they read, and reference back to the article with supporting "facts". They can write their response in their notebook or on a separate slip of paper. The purpose of this is to draw evidence from an informational text so that they can research, analyze and then reflect on their question of "Why can't we just grow more?".
- Possible class discussion questions:
  1. What are the three components that the article mentions that create the "The Great Balancing Act"?
  2. How are the vocabulary terms we reviewed earlier (ecosystem and nonrenewable resources) related to the article?
  3. What impact is agriculture having on the environment and our natural resources?
  4. How can we find balance between feeding a growing population and caring for our environment and natural resources?
- **OPTIONAL HANDOUT IN LIEU OF ANNOTATING THE ARTICLE:** Rather than annotating the article while reading, students can use the optional handout with guiding questions for the article. Please see the The Great Balancing Act- Reading Guide (Student Version) and the accompanying teacher guide titled The Great Balancing Act- Reading Guide (Teacher Version) in the Resources section.

3. Analysis Activity with Chart

- For the following activity, the class will focus on the chart called "A Menu for Sustainable Food Future" (pages 10-13) at the end of the article, which includes options ("menu items") of how to achieve a sustainable, food secure future, with potential impacts (poverty alleviation, gender, ecosystems, climate, and water) identified .
- Prior to looking at the chart as a class, take a moment and review the stakeholders involved from Lesson FS3. As a class, discuss and determine which 5 stakeholders students believe are most impacted by perturbations in the food security network. Note to teacher: there is no right answer here, as long as students can justify their determination. One suggestion is to look at their causal loop diagram from Lesson FS4, for a visual of the system. Once five stakeholders have been identified, this is the list you will use to evaluate the chart at the end of the article. By identifying 5 stakeholders, this gives the class a common set of individuals to compare across all "menu items" and focuses the classes' attention on looking more in depth at how each of these 5 stakeholders is impacted by each "menu item".
- Examples of stakeholders that might be most impacted might be: urban citizens in a developing country, representatives of agricultural supply, Earth's water supply, small farmers in developing countries and the environment. However, any 5 stakeholders can work for this activity, as long as the class is in agreement and students can justify their reasoning for choosing that stakeholder.
- Have students study the chart and discuss as a class, how to read it. In looking at the chart, orient pages 10 and 11 so they are side-by-side, and do the same with pages 12 and 13. To read the chart, refer the the example below:
  - Example: Refer to the first course heading labeled "Hold down consumption". Read horizontally across the chart and you will see a column dedicated to menu item, description, performance against criteria (poverty alleviation, gender, ecosystems, climate, water), comment, food availability and GHG (greenhouse gas) emissions. If the "Increased Food Availability" and "Decreased GHG Emissions" columns have an X below them, that menu item is meeting that need; therefore, if no X is present, that menu item is not meeting that need. Be sure to study the key at the top right of the charts to understand what each icon represents. This is a highly intense thinking skill/analysis activity!
  - For example: using one of the stakeholders from the example above (urban citizens in a developing country) focusing on the first menu item, "reduce food loss and waste". This could have a positive impact on urban citizens in a developing country, because it is a manageable, actionable item that anyone could focus on. This would not only limit the amount of loss of food, but the resources it takes to acquire that food.
- Place students in groups of 2-3 to analyze the chart. Hand out the Lesson FS5 Balancing Act Article Chart Analysis Handout (1 per student). Each group will analyze each menu item on the chart using the 5 stakeholders determined in step 2. Note to teacher: to save time, give each group just a few of the menu items to focus on, then have each group share out what they determined through their analyses to the class so that students can record their information. For each "menu item" they will identify the following and record the information on the handout: a) which one of the 5 identified stakeholders would be impacted the most by that particular menu item b) would they be impacted positively or negatively, c) how would they be impacted (justifying their answer), d) whether or not they agree with the dots on to the right of the menu item (justifying their answer), e) what is the overall impact to food availability and GHG emissions and f) do they agree that it will have the same impact on food availability and GHG emissions as indicated on the chart? They must justify their answer. Note to teacher: See an example answer key, based on the five stakeholders above, developed by the 2017 Project Feed 1010 Ambassadors in the Lesson FS5 resources at isbscience.org.
- As a class, discuss each of the menu items. Focus on which stakeholder they determined is impacted by each "menu item" and whether that impact is positive or negative. One "menu item" to point out as a discussion point would be, "boost yields through attentive crop and animal breeding". This is a great "menu item" to discuss because all of the performance against criteria are neutral. Focus also on a couple of the "menu items" as well as the link between food availability and GHG emissions (the last two columns) for that "menu item".
  - One suggestion is to focus on the following 4 "menu items": reduce then stabilize wild fish catch, improve the feed efficiency of ruminant livestock, make fertilization more efficient and manage rice paddies to reduce emissions. All of these examples have an impact on either food availability or GHG emissions, but not both. Discuss why this might be the case.

TEACHER INSTRUCTIONS CONTINUED

4. **Building Your Case:** have the students complete the questions for FS Lesson 5 on the "Building Your Case" worksheet. The goal of this activity is to continue building their case to solve the food security crisis in their country, which they will be presenting (as a summative assessment) at a UN summit.
5. **Exit Ticket:** Tell the students that to wrap up the lesson, we are revisiting the concept of ecosystems and nonrenewable resources. Give students time to complete the prompts listed below (from the Lesson 5 slides in the Food Security Vocabulary PowerPoint) in their notebook. Time permitting, students can share out their responses.
    - Show how an ecosystem can be illustrated as a system
    - How would overuse of a nonrenewable resource affect the ecosystem you just illustrated?

MODIFICATIONS

- In the interest of time and/or student skill level, the teacher may wish to break up the article chart into smaller pieces and have each group only analyze a few of the "menu items" and how stakeholders are impacted by them. This will allow the lesson to proceed faster and will not be as overwhelming for students. When the lesson was piloted by interns in 2017, students were broken up into 3 groups and the chart was broken up into three equal segments (~ 5-6 menu items for each group to analyze). See the example of the table filled out and broken up on the SEE website. If students have internet access and computers, they can work collaboratively on a shared digital version of the document rather than filling out physical copies and sharing information later.

RESOURCES

- SEE website: isbscience.org
    - Food Security Vocabulary PowerPoint
    - Digital version of Balancing Act Article Chart Analysis Handout for modification
    - Example Balancing Act Article Chart Analysis Handout
- Searchinger, T., et al. The Great Balancing Act Installment 1, World Resource Institute, http://pdf.wri.org/great_balancing_act.pdf
- The Great Balancing Act- Reading Guide (Student Version)
- The Great Balancing Act- Reading Guide (Teacher Version)
- Balancing Act Article Chart Analysis Handout

LESSON 5: WHY DON'T WE JUST GROW MORE?

RESOURCES: THE GREAT BALANCING ACT - READING GUIDE (STUDENT VERSION)

As you read The Great Balancing Act, answer the following questions. This will serve as a guide to future class discussions about solutions to the problem of feeding the world's population by 2050.

1. State the three needs that compose the "Great Balancing Act".

2. What are the three environmental impacts that agriculture contributes to?

3. Look at Figure 3. Name two areas of the world that will increase to a higher water stress level by 2025.

4. If all the food produced in 2009 was evenly distributed (calorie wise) to all the people in 2050, it would come up short by _____ kcal per person per day.

5. If the current rate of food loss and waste remained at the same rate in 2050, we would be short _____ kcal per person per day.

6. With an increase demand in food, comes and increase in the demand for crops. The article recommends that we increase the production of crops from _____ trillion kcal per year in 2006 to _____ trillion kcal per year in 2050.

7. In order to balance the needs of the environment with the needs of crop production, crops in the future must be grown without the increased use of _____ and _____. (Name two)

8. The article mentions possible solutions/menu items. What are the three main courses where these menu items would aid in creating a sustainable food future?

LESSON 5: WHY DON'T WE JUST GROW MORE?

RESOURCES: THE GREAT BALANCING ACT - READING GUIDE (TEACHER VERSION)

As you read The Great Balancing Act, answer the following questions. This will serve as a guide to future class discussions about solutions to the problem of feeding the world's population by 2050.

Teacher Version- Answers in Red

1. State the three needs that compose the "Great Balancing Act".
   1 - close the gap between food available now and needed by 2050
   2 - agriculture needs to contribute to inclusive economic and social development
   3 - world needs to reduce agriculture's impact on the environment and natural resources

2. What are the three environmental impacts that agriculture contributes to?
   Ecosystems, Climate, and Water

3. Look at Figure 3. Name two areas of the world that will increase to a higher water stress level by 2025.
   Students could answer India, China, Great Plains in the US, Central America or Central Africa

4. If all the food produced in 2009 was evenly distributed (calorie wise) to all the people in 2050, it would come up short by _____200_____ kcal per person per day.

5. If the current rate of food loss and waste remained at the same rate in 2050, we would be short _____900_____ kcal per person per day.

6. With an increase demand in food, comes and increase in the demand for crops. The article recommends that we increase the production of crops from ____9,500____ trillion kcal per year in 2006 to ____15,000____ trillion kcal per year in 2050.

7. In order to balance the needs of the environment with the needs of crop production, crops in the future must be grown without the increased use of _____ and _____. (Name two)
   Students could answer scientifically bred seeds, synthetic fertilizers, pesticides, or water use

8. The article mentions possible solutions/menu items. What are the three main courses where these menu items would aid in creating a sustainable food future?
   1st - items that help close the food gap by reducing growth in food consumption
   2nd - items that help close the food gap by increasing food production on existing agricultural land areas
   3rd - items that reduce the environmental impact of food production but do not necessarily lose the food gap (this focuses more on the stress to the environment and the importance of sustainability for future crop production)

LESSON 5: WHY DON'T WE JUST GROW MORE?

RESOURCES: BALANCING ACT ARTICLE CHART ANALYSIS HANDOUT

COURSE	MENU	WHICH OF THE 5 IDENTIFIED STAKEHOLDERS WOULD BE IMPACTED BY THIS MENU ITEM?	WOULD THEY BE IMPACTED IN A POSITIVE OR NEGATIVE WAY?	HOW WOULD THEY BE IMPACTED? JUSTIFY YOUR ANSWER	STATE WHETHER YOU AGREE OR DISAGREE WITH THE PLACEMENT OF DOTS FOR THE MENU ITEM. JUSTIFY YOUR ANSWERS	WHAT IS THE OVERALL IMPACT TO FOOD AVAILABILITY AND GHG EMISSIONS?	DO YOU AGREE THAT THE MENU ITEM WILL HAVE THE IMPACT INDICATED ON FOOD AVAILABILITY AND GHG EMISSIONS? JUSTIFY YOUR ANSWER
HOLD DOWN CONSUMPTION	REDUCE FOOD LOSS AND WASTE						
	REDUCE OBESITY						
	EAT FEWER ANIMAL PRODUCTS						
	SHIFT MEAT CONSUMPTION AWAY FROM BEEF						
	ACHIEVE REPLACEMENT FERTILITY RATES						
	REPLACE BIOFUEL DEMAND FOR FOOD CROPS						

LESSON 5: WHY DON'T WE JUST GROW MORE?

RESOURCES: BALANCING ACT ARTICLE CHART ANALYSIS HANDOUT

COURSE	MENU	WHICH OF THE 5 IDENTIFIED STAKEHOLDERS WOULD BE IMPACTED BY THIS MENU ITEM?	WOULD THEY BE IMPACTED IN A POSITIVE OR NEGATIVE WAY?	HOW WOULD THEY BE IMPACTED? JUSTIFY YOUR ANSWER	STATE WHETHER YOU AGREE OR DISAGREE WITH THE PLACEMENT OF DOTS FOR THE MENU ITEM. JUSTIFY YOUR ANSWERS	WHAT IS THE OVERALL IMPACT TO FOOD AVAILABILITY AND GHG EMISSIONS?	DO YOU AGREE THAT THE MENU ITEM WILL HAVE THE IMPACT INDICATED ON FOOD AVAILABILITY AND GHG EMISSIONS? JUSTIFY YOUR ANSWER
PRODUCE MORE FOOD WITHOUT LAND EXPANSION	BOOST YIELDS THROUGH ATTENTIVE CROP AND ANIMAL BREEDING						
	"LEAVE NO FARMER BEHIND"						
	PLANT EXISTING CROPLAND MORE FREQUENTY						
	IMPROVE SOIL AND WATER MANAGEMENT						
	EXPAND ONTO LOW-CARBON DEGRADED LANDS						
	INCREASE PRODUCTIVITY OF PASTURE AND GRAZING LANDS						

LESSON 5: WHY DON'T WE JUST GROW MORE?

RESOURCES: BALANCING ACT ARTICLE CHART ANALYSIS HANDOUT

COURSE	MENU	WHICH OF THE 5 IDENTIFIED STAKEHOLDERS WOULD BE IMPACTED BY THIS MENU ITEM?	WOULD THEY BE IMPACTED IN A POSITIVE OR NEGATIVE WAY?	HOW WOULD THEY BE IMPACTED? JUSTIFY YOUR ANSWER	STATE WHETHER YOU AGREE OR DISAGREE WITH THE PLACEMENT OF DOTS FOR THE MENU ITEM. JUSTIFY YOUR ANSWERS	WHAT IS THE OVERALL IMPACT TO FOOD AVAILABILITY AND GHG EMISSIONS?	DO YOU AGREE THAT THE MENU ITEM WILL HAVE THE IMPACT INDICATED ON FOOD AVAILABILITY AND GHG EMISSIONS? JUSTIFY YOUR ANSWER
PRODUCE MORE FOOD WITHOUT LAND EXPANSION	REDUCE THEN STABILIZE WILD FISH CATCH						
	INCREASE PRODUCTIVITY OF AQUACULTURE						
REDUCE EMISSIONS AND OTHER IMPACTS FROM OTHER AGRICULTURE ACTIVITES	IMPROVE THE FEED EFFICIENCY OF RUMINANT LIVESTOCK						
	MAKE FERTILIZATION MORE EFFICIENT						
	MANAGE RICE PADDIES TO REDUCE EMISSIONS						

LESSON 6: WHERE DOES OUR FOOD COME FROM?

THE BIGGER PICTURE

How does our food get from farm to table and what resources are required to get it there? In this activity, students will play a game to produce pizza. While the game uses economics as a driving force to model food production, students must use a systems thinking approach to strategize and make decisions. Various food production techniques can be utilized, each with their own costs and benefits; therefore, students will need to make a series of decisions to grow crops while also considering the impact they impart on the environment. Weighing economic interests against resource use and environmental consequences can be challenging! Students also learn to adapt their food systems in the face of environmental catastrophes and will gain understanding of how agriculture and food production is a system. Many factors (social, environmental, economic, etc) impact that system; however, some of these variables are not included due to time constraints.

OBJECTIVES

What students learn

Students understand not only the economic, but also the environmental costs associated with production and consumption of food products and how external variables can affect them. Students recognize the agricultural and food production system is complex and external costs may not show up on the final price tag!

What students do

Students play a game and become business people who are challenged to grow ingredients to make sustainable food products in the face of economic difficulties and changing environmental conditions. Students strategize and make decisions to build a food system that is profitable while also balancing their system's impact on the environment.

TIME

60 - 90 minutes - 1 - 2 class periods

STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS-LS4-6; DCI: LS4.D; SEP: Using Mathematics and Computational Thinking; CC: C&E
- NGSS PE: HS- ESS3-2; DCI: ESS3.A; SEP: Engaging in Argument from Evidence; CC: Influence of ETS
- NGSS PE: HS-ESS3-4; DCI: ESS3.C; SEP: CEDS; CC: S&C; Influence of ETS
- NGSS PE: HS-ETS1-1; DCI: ETS1.A; SEP: Asking Questions and Defining Problems; CC: Influence of ETS
- NGSS PE: HS-ETS1-2; DCI: ETS1.C; SEP: CEPS

PREREQUISITES

Students should have completed the previous lessons (1-5) in the FS module, as well as the cell phone network activity (Introduction to Systems). A baseline understanding of HS-ESS2.C: Roles of Water in Earth's Surface Processes and HS-ESS 3.C: Human Impacts on Earth's Systems is helpful but not required.

BEFORE CLASS

This game is designed for 6 individual players per game board or 2 students playing as a team in a group of 8 students (4 teams total). Think ahead about seating charts and place at least one student in each group who can be the "banker" - the distributor of money and resources from the Global Bank. Teachers may want to pre-select students who are a good fit for this role, and introduce the game rules to them ahead of time. Gather the following materials before class:

Number of each document or item needed												
Group type	Game Board	Crop Card Sheet	Crisis Card Sheet	Invest-ment Card Sheet	Reso-urce Card Sheet	Global Fund ($25) Sheet	Global Fund ($100) Sheet	Student Game Rules Sheet	Student Game Analysis Sheet	Resource Tracker Sheet	6-sided Dice	Paperclips (Carbon energy chips)
6 individ-uals	1	5	1	7	12	7	4	6	6	6	1	1 box
4 teams of 2	1	3	1	5	10	5	3	4	8	4	1	1 box

Students will need their "Building Your Case" worksheet. In addition, download the Food Securtity Vocabulary PowerPoint. All of the *Modeling Sustainable Food Systems* resources are on the SEE website: isbscience.org.

TEACHER INSTRUCTIONS

- The goal of the lesson is for students to understand the complexity of food production and how important it is to take a systems approach to solving an issue. In this lesson, students will play a game and will need to produce as many pizzas as they can. The winning team is determined by the following equation, which takes into account pizzas produced, environmental impact, and monies used: (profit from pizzas produced/global funds used) – net carbon energy chips = Food Production Score (FPS).
- Each player is given global funds (money) at the start of the game, which allows them to purchase resources to produce the crops required to make these pizzas. Selling their finished pizza product back to consumers helps replenish their global funds. Players can also use these global funds to invest in technologies and natural resources that mitigate their impact on the environment. It is important to read and familiarize yourself with the rules of the game before playing.

TEACHER INSTRUCTIONS CONTINUED

1. **Warm-up:** Show Food Security Vocabulary Powerpoint. Have students answer the formative questions in their notebooks.
   - What is the definition of a "Greenhouse Gases?
   - What is the definition of a "Subsidy"?

   Get responses from 2 or 3 students. Explain that Merriam-Webster's dictionary describes the terms as follows:
   - Greenhouse Gases: gases that pollute the air and cause the warming of the Earth's atmosphere
   - Subsidy: a grant by a government to a private person or company to assist an enterprise deemed advantageous to the public
2. **Introducing the Game:** Tell the students they will be playing a game to simulate the production of a universally well known food. What food can they think of that is a favorite among teenagers, universally known, and simple to make? Then say, "why not pizza"?
   - Introduce students to their roles as players: each student is a farmer, investor and distributor in a food production system to produce enough pizza to feed the country.
   - To win the game: Players have to produce as many pizzas to feed the country as they can while having the lowest impact on the environment. The winning team is determined by the following equation, which takes into account pizzas produced, environmental impact, and monies used: (profit from pizzas produced/global funds used) – net carbon energy chips = Food Production Score (FPS).
3. **Introducing Game Cards:** All of the game cards introduced below can be found in the Game Cards document and Global Funds document (also referenced in the Student Game Rules document). Place students into their groups (maximum of 6 individuals or 4 teams of 2 players each). Each group should be seated around their game board (1 game board per group) with a Resource Tracker (1 per student), and a set of game cards and global funds per game board. Use the following steps to introduce the cards used in the game.
   - Start by stating that all the details about each card can be found on the Student Game Rules document. Tell groups that each player starts with $1000 Global Fund dollars at the beginning of the game. Each player should receive the following breakdown of Global Fund dollars to start the game: 7-$100 bills and 12-$25 bills equalling $1000 GF.
   - Hold up a carbon energy chip (paperclip). Tell them as they are busy producing food through their food production system, they will also be making an impact on the environment (because growing and producing food has a carbon footprint due to the production of greenhouse gases). Each time they grow a crop or produce food there is a carbon energy chip cost. If a player has accumulated 20 carbon energy chips they need to find a source to offset their carbon footprint (plant trees or invest in solar energy or hydroelectric power).
   - **Resource cards (land, water, and fertilizer):** Hold up an example of each of the resource cards and explain what they are. The resource cards are required to harvest a crop. Each crop has a specified amount of each resource, indicated on that crop card (can also be viewed on the Resource Tracker document).
   - **Crop cards (wheat, tomato, basil, cheese):** Pictures of the cards can be seen on their Resource Tracker. They must accumulate the resources to produce each specific crop throughout the growing season. Ask students to brainstorm what resources they would need to grow wheat. Ideas they may come up with are water, sunlight, nutrients and land. Then have students look at the Resource Tracker to see how this is information is conveyed on the crop cards. For example: to produce a wheat crop, players must have 4W, 4L,1F. These values represent the resources required to harvest 1 wheat crop (W = water, L = land, F= fertilizer). SH = Spring harvest and +5C = 5 carbon energy chips (paper clips) acquired from producing that crop. Note: there are an additional +3C (carbon energy chips) that must be acquired from the use of fertilizer used to grow that crop (as indicated below the list of resources required) for a total of +8C accumulated through growing wheat on land. If students set up an aquaponic system to grow tomatoes and/or basil (the only crops allowed with aquaponics), no carbon energy chips for fertilizer are acquired since fertilizers are not required to grow that crop in aquaponics. Therefore, instead of receiving 10 carbon energy chips when harvesting the tomato crop (using land and fertilizer), players can eliminate those typically acquired from using fertilizer (+9C) and accumulate only +1C from harvesting that tomato crop. Players must have one of each crop card to make one pizza during "Production" (1 basil + 1 tomato + 1 wheat + 1 cheese= 1 pizza).
   - **Two types of water cards ("rainwater" and "water"):** "Rainwater" cards are free and each player accumulates 3 rainwater cards at the beginning of each rainy growing season; however, these events only happen twice in a growing year. If players need more water to grow crops, they can purchase "water" cards to be used for crop production only after they have invested in an irrigation system. Each crop requires a separate irrigation system.
   - **Investment cards (trees, aquaponics, hydroelectric, irrigation system, and solar):** Tell the students that throughout the game, they will have an opportunity to use their global fund (GF) dollars to invest in several methods to improve the efficiency and sustainability of their food production systems. Some of these investment opportunities (trees, hydroelectric, and solar) allow players to receive a carbon energy chip credit because they're adding value back into the environment due to their sustainability. In other cases, these methods improve efficiency of food systems. For example: If students choose to invest in an irrigation system, this will allow them to purchase water and not be reliant on rainwater to grow crops; however, each crop requires it's own irrigation system. Therefore, if a player buys an irrigation system and they purchase water for their wheat crop, the irrigation system remains with the wheat crop. Players have the opportunity to purchase up to 4 irrigation systems (one system per crop) if they wish. Students must place their irrigation system card on their resource tracker over the crop they assigned it to.
   - Show your students how they will track their resources during the game using the **"Resource Tracker"** to record carbon energy chips acquired, any investments that provide carbon energy chip credits, global funds used, and the profit they collect from pizzas produced at the end of each round.

TEACHER INSTRUCTIONS CONTINUED

4. **Progression Through the Game Board:**

- Tell students the next series of steps is to set up their "growing system" before they begin round 1 of producing pizza. At this point the player designated as the "banker" (who should be coached ahead of time) starts the game giving each player their Global Fund dollars ($1000GF) Throughout the game the "banker" continues to play the role serving as the distributor of money and resources for the other players.
- Students can now roll the die and draw land cards (number on die = number of land cards. They will begin the game with different amounts of land cards (1-6 land units). As the game progresses they may purchase additional land but only during the investment stage. Each land unit is $50 GF. Land is not equal when you start the game -- Ask students why? How does this simulate land distribution in real life? When a player wants to harvest a crop, they must have the dedicated land cards for that crop, as well as any other resources needed (i.e. water, fertilizer). The cards represent arable land, which remains with the player throughout the game unless the land is sold back to the Global Bank or lost to a crisis (during the 2nd year; step 18). Give each group a chance to determine their land cards before moving on.
- Tell students to begin playing, starting with growing year 1, and to proceed through the entire game board using the "Student Game Rules" document as a guide. Each player takes a turn during each stage of the game. They will follow each step on the game board, only moving to the next stage once all players at the table have taken a turn. For each game board, there needs to be a marker/token to signify where the group is on the game board as they move through the game. The stages progress as follows: 1) Rainy Growing Season, 2) Making Investments, 3) Dry Season 4) Harvesting, 5) Producing pizza and selling the pizzas back to the Global Fund.
- **Rainy Growing Season:** Have the banker for each game hand out three rainwater cards to each player once players reach the "Rainy Growing Season". These seasonal rains (3 rainwater cards) only come two times in each growing year, once per round. Players must strategize how they will obtain the water necessary to grow the crops they need. As the game progresses, they will have seasons where they will collect more rain, but it is important to calculate the amount water needed per year to grow the crops. Give students time to make this calculation to predict the water needed for the crops they will grow. To calculate, they can reference their Resource Tracker document which gives them information about the requirements of each crop.
- **Making Investments:** Students all get a chance to invest and improve their systems during the investment stage only.
- **Dry Season:** Players will lose water cards based on the roll of the die. If the die comes up with an odd number, that player only loses one water card. If the die comes up with an even number, they lose two water cards. This simulates how different areas of the country lose water at different rates during the dry season.
- **Spring or Fall harvest:** players can only harvest the crops identified on the game board. For example: during Spring harvest (SH) they can produce wheat and basil, during the Fall harvest (FH) they can produce tomato and cheese. To produce a crop, they must have the dedicated resources (land, water, fertilizer) for that crop as noted on the game board and the crop cards.
- **Production:** Once a player has harvested all 4 ingredients (crops) for the pizza and have reached "Production", they can exchange the 4 crop cards for a pizza card and will also accumulate 1 carbon chip. Example: 1 unit wheat + 1 unit tomato + 1 unit cheese + 1 unit basil = (1 pizza + 1 carbon chip). Players can sell their pizza to the Global Bank during the production round to receive their $50 profit per pizza.
- At the end of each round (harvest season), students will use their "resource tracker" to monitor their progress in the game. They must record the following information: global funds used during the round, carbon credits (from solar, hydroelectric, or trees), carbon energy chips acquired, and the profit from the pizzas produced. The end of two rounds (harvest seasons) will signify one whole growing year and players can then progress onto growing year 2.
- **Growing Year 2 (rounds 3 & 4) - Crisis Management**: Give students a heads up that before they begin growing year 2, they will face a crisis and be required to adapt their current system to be able to handle that crisis. Each student will be required to pick up a crisis card, which describes a situation they now face as food producers and the consequence of that crisis. The crisis each student faces will take effect at the beginning of rounds 3 and 4.
- Once all the players have completed the final harvest and production and sold their last pizzas they can record final values for the growing seasons on their Resource Tracker.
- Once a group/team of students has completed two growing years, they need to determine the winner through calculating their Food Production Score (FPS) and analyze their results using the Student Game Analysis worksheet.

5. **Building Your Case Worksheet:** Students immersed in the game will now understand more about the process of growing and producing food from planning the crops, to investing in future improvements to the system. Many countries suffer from limited resources that require different systems to produce food. Ask students to apply what they learned from this game to the Lesson 6 questions (1-3) in the Building Your Case worksheet.
6. Students should complete the **Student Game Analysis Worksheet** (in class or as homework) to review the concepts learned throughout the game and the vocabulary words from the beginning of the lesson. These questions can be used as a formative assessment. **NOTE: For question 10, steps of the "engineering design process" recognized by NGSS include: 1) Define the problem, 2) Come up with ideas (brainstorming), 3) Select the most promising design, 4) Communicate the design, 5) Create and test the design, and 6) Evaluate and revise the design. Be sure to stop and discuss the answer to this question as a class before proceeding to question 11.**

RESOURCES

- SEE website: isbscience.org
  - Food Security Vocabulary PowerPoint
- Student Game Rules
- Game Board
- Game Cards
- Global Fund Dollars
- Student Resource Tracker
- Student Game Analysis

RESOURCES: STUDENT GAME RULES

To win

Players have to produce as many pizzas to feed their country as they can. The winning team is determined by the following equation, which takes into account pizzas produced, environmental impact, and monies used: **(profit from pizzas produced/ global funds used) – net carbon energy chips = Food Production Score (FPS).**

To Start the Game

1. Each player gets $1000 in Global Funds (GF) dollars at the start of the game. The Global Bank distributes the Global Funds. Once each player's money is depleted, they cannot get more funds until they produce a pizza and sell it to the Global Bank.
2. Students roll the die to determine the number of land cards they will acquire. Roll a 3 = 3 land units (1-6 units of land are possible). Students begin designing their farming and pizza production strategies and determine which cards they need to carry out their plan.

Progression Through Game Board

Each "growing year" is made up of 2 "rounds" (from "rainy growing season" through "production" on the game board) to signify the two (Fall and Spring) harvest seasons.

1. Rainy Growing Season: players roll the dice to receive rainwater cards. Rolling a 3 = 3 rainwater cards given to that player.
2. Make Investments: players can use Global Funds to purchase Resource cards (ex: water, land, fertilizer and energy) and make other investments in their system. Trade in Global Funds for adaptations to food production systems. Each investment option comes with it's own costs and benefits. See investment options below:

Investment Descriptions and Costs

Investment Item	Cost	Rules
Land	$50 each	Land can be purchased or sold at $50 per card. Each land card can only be used one time per round and for only one crop at a time. After a harvest, players may switch land to grow another type of crop.
Fertilizer	$25 each	Purchase fertilizer during the investment stage. Add +3 carbon energy chips each time you purchase a fertilizer card. Players use fertilizer cards to grow each crop.
Irrigation System	$100 each	Purchase this system to get more water. This system makes it possible to purchase "water" cards ($25 per 2 water cards) and reduce reliance on rainwater. Each system purchased must be assigned to one crop. That irrigation system must remain with that crop, along with any water purchased for that irrigation system. Place that irrigation system card on your resource tracker on top of the assigned crop picture.
Aquaponic System	$100 each	Only used to grow basil and tomatoes. This reduces water cards 50% and doesn't require any fertilizer! You must purchase 2 fish cards per aquaponic system in order for the system to produce food. This is the only food production strategy that doesn't require the use of land cards. Example: If a player has a crop that needs 2 water cards, 2 land cards, and 3 fertilizer cards, the player with an aquaponic system can reduce resource requirements to 1 water, 0 land, and 0 fertilizer cards.
Fish	$50 per Tilapia (fish)	2 fish are needed to operate 1 aquaponic system.
Solar Energy	$100 each	This reduces your carbon footprint by allowing you to remove 2 carbon energy chips each round. Each solar energy card requires 1 land card for space and can no longer be farmed.
Hydroelectric System	$100 each	This reduces your carbon footprint by allowing you to remove 2 carbon energy chips each round. Each hydroelectric card requires 1 land card for space and can no longer be farmed.
Trees	$50 each	Each tree card allows you to remove 2 carbon energy chips each round, but the space needed to plant trees can no longer be farmed. A maximum of 4 trees can be planted on each land unit (therefore up to 8 carbon energy chips can be removed each round per land unit).

RESOURCES: STUDENT GAME RULES CONTINUED

3. Dry Season: Roll the dice to signify the loss of water during the dry season. An even number = lose 2 rainwater cards, if an odd number = lose 1 rainwater card. If a player rolls and does not have any additional water to turn in, they will not be penalized any farther. There water will be at zero until the next rainy growing season or investment stage. Water cards that are allocated for a particular crop can be taken away during the dry season.
4. Harvest Seasons: These harvest seasons are an opportunity for players to acquire their crops based on the resources they've accumulated throughout the game. Every time players harvest a crop, they gain the number of carbon energy chips for that respective crop (as stated on the card). There are two harvest seasons:
   - **Spring harvest** - during this season, you can harvest wheat and basil crops only
   - **Fall harvest** - during this season, you can harvest tomatoes and cheese only

   Crop cards (tomato, basil, wheat, and cheese):
   - Every pizza requires 1 of each crop card
   - Each crop requires a different amount of land (indicated on each crop card)
   - Players utilize water, fertilizer, land cards in order to harvest (acquire) each crop during the appropriate harvest season
   - Resource cards (rainwater, water, fertilizer, and land) are collected and exchanged for the each crop card during the harvest seaons. Once a crop is "harvested", players will hold onto it until the "production" stage.
   - Once a player has grown each of the 4 crops, they can exchange them for 1 pizza
   - **Reading Crop Cards Example:**
     - Wheat: "4W, 4L, SH, 1F + 5C" (+3C fertilizer + 5C wheat production)
     - These values represent the resources required to harvest 1 wheat crop (W = water, L = land, SH = Spring harvest, F = fertilizer) and the carbon energy chips (C) the player accumulates when they harvest a wheat crop (+5C). Below these values on the card, the number of carbon energy chips players accumulate due to the fertilizer used is also listed (+3C in this example). Therefore, if players use an aquaponic system rather than land to produce a crop, they will not accumulate the carbon-energy chips from fertilizer use.

5. Production: Players exchange 1 of each crop card (1 unit wheat + 1 unit tomatoes + 1 unit cheese + 1 unit basil) to make 1 pizza. In exchange, players are given $50 GF in "pizza profit" per pizza from the Global Bank and gain 1 carbon energy chip per pizza. If you don't have enough resources for the 4 crops to produce pizza at production stage, you can hold onto those crop cards for a later round and wait for other players to produce their pizzas. Players may not sell a crop for GF dollars, they can only sell pizzas.
6. Crisis Cards: Each player draws 1 crisis card only at the beginning of year 2 (round 3). The crisis described on this card will take effect until the end of the year (through round 4). The card tells players that there is a catastrophe of some kind and their food system must be adapted to survive the change. Global funds can be used to improve/adapt their system during the investment period.

Using the Resource Tracker

- **Tracking your cards:** As you accumulate resource cards (water, land, fertilizer), place the card(s) in the space provided on the resource tracker for the crop you want that resource allocated to. (Example: 1 wheat crop = 4 land units (4L), so all four land cards are stacked on the wheat growing area). To allocate land to other investments (trees, hydroelectric, solar), place the investment card and the land required for that investment together off to the side of the board to keep track of how the land is being used.
- **Scoring:** At the end of each round (after "production" periods), record the following information in the "resource tracker": total global funds you used, the carbon credits you acquired from various investments, the carbon energy chips you accumulated through production, and the profit from each pizza you produced. Eventually, these numbers will be used in the "student game analysis worksheet" to calculate the winning team based on their Food Production Score (FPS): (profit from pizzas produced/global funds used) – net carbon energy chips = Food Production Score (FPS)

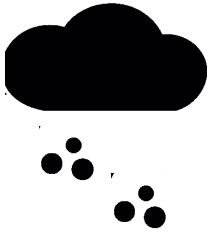
Carbon Energy Chips

- Carbon energy chips (paper clips) are acquired any time a player harvests a crop or produces a pizza. During harvest, the number of carbon energy chips is determined by the crop being harvested (as indicated on the crop card). Each time a pizza is produced, that player accumulates 1 additional carbon energy chip. If a player fills their cup with 20 carbon chips, this exceeds allotted carbon footprint and the environmental impact has reached its maximum threshold. If ALL the players reach maximum threshold, the entire table of players loses the game!
- Carbon energy chips can be removed (as a carbon credit) if a player invests in alternative energy sources (solar energy or hydroelectric) or planting trees. See the "investments" section for specifics on carbon credit amounts for each option.

LESSON 6: WHERE DOES OUR FOOD COME FROM?

RESOURCES: GAME BOARD

DRAW CRISIS CARD	RAINY GROWING SEASON	MAKE INVESTMENTS	DRY SEASON	SPRING HARVEST	PRODUCTION
					
BEGINNING OF ROUND 3 ONLY	+3 RAINWATER CARDS		-1 OR -2 EITHER TYPE OF WATER CARD	BASIL AND WHEAT	PIZZA

RAINY GROWING SEASON	MAKE INVESTMENTS	DRY SEASON	FALL HARVEST	PRODUCTION
				
+3 RAINWATER CARDS		-1 OR -2 EITHER TYPE OF WATER CARD	CHEESE AND TOMATOES	PIZZA

RESOURCES: STUDENT GAME ANALYSIS

At the end of the game, add up the values you have entered on your Resource Tracker for each round below:

Round	Global Fund $ Used	Carbon energy chips accumulated	Carbon credits from trees, solar, hydroelectric	Net carbon energy chips	Profit from pizzas ($50/ pizza)	Food Production Score (FPS): see equation below
Rounds 1-2 end total (growing year 1)						
Rounds 3-4 end total (growing year 2)						

To calculate your Food Production Score (FPS):

(_____/ _____) - _____ = _____

(profit from pizzas produced/global funds used) – net carbon energy chips = FPS

Game Analysis Questions:

1. What about your food production strategy changed as you played the first two rounds?

2. What changes did you make in your food production system in the rounds 3-4 (post-crisis planning)? Why?

3. Add up the values for rounds 1-2 and round 3-4 separately in the table above. Compare the total points before (rounds 1-2) and after (rounds 3-4) the "crisis". What differences do you notice in these values, if any? Why?

4. If the game continued beyond round 4 (post-crisis), what next steps would you take in your game strategy to improve your food production system? Name 3 strategies you could try and justify how that strategy would benefit your food production system.

5. This game is a simple model of the food supply chain. Illustrate the steps taken in this game to create food from raw materials to the final product (pizza). How does this game compare to the "real" food supply chain? List 3 steps that may be missing.

6. What do "Global Funds" represent? Explain why this needs to be factored into the overall Food Production Score.

7. Do you think the Food Production Score accurately represents the inputs and outputs of a food system? Why or why not?

8. Do you think the Food Production Score is a good way to measure how efficient and sustainable your system is? Justify your response.

RESOURCES: STUDENT GAME ANALYSIS CONTINUED

9. In comparing food production scores, what does it mean if one player has a larger negative score than another (in terms of their food production efficiency and sustainability)?

10. When deciding how to design any system, what steps do you take to determine how you want to create it? Think through the steps you took when deciding how to create your food production system. This is called the "engineering design process". As a group, brainstorm and list the steps we take to design a system.

11. Using the systems network you created in question 5, go back and label the parts that match each step of the engineering design process, then share your thoughts with a partner. Be ready to share what you found with the class.

Wrap-up Questions:

1. List 3 ways greenhouse gases are produced in agriculture.

2. List 2 ways climate change could affect crop production.

3. How is the availability of a crop related to the price of that crop?

4. How would providing subsidies to farmers affect the price of a crop?

5. What relationships exist between water and land used during crop production, carbon emitted, and price of the crop?

6. Based on your knowledge of food production systems, would there ever be a time when it is more efficient to produce tomatoes in Chile and have them shipped to you vs. growing them locally? Justify your answer.

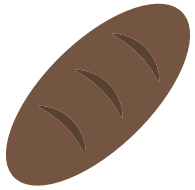
7. Oh NO! It doesn't rain for 1 year and then a downpour produces 25 cm of rain in an hour (in a region that, on average, receives 10 cm per year). Explain the consequences of this event on the food production system. Give an example of a positive and negative feedback loop you may see as the system tries to stabilize.

LESSON 6: WHERE DOES OUR FOOD COME FROM?

RESOURCES: RESOURCE TRACKER

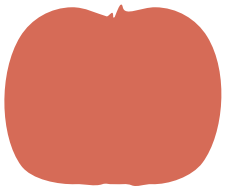
Player Name _____

WHEAT
4W, 4L, SH, 1F +5C
(+3C fertilizer, +5C wheat production)



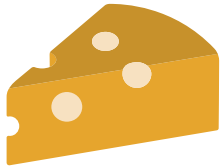
The real value of wheat:
W = 1300 liters/kg
L = 400 m^2 year x 10^3/kg
C = 0.65 kg CO^2e/kg

TOMATO
2W, 2L, FH, 3F +1C
(+9C fertilizer, +1C tomato production)



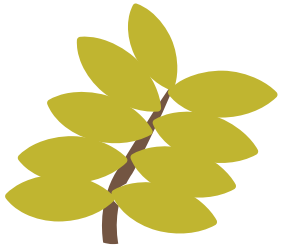
The real value of tomatoes:
W = 180 liters/kg
L = 30 m^2 year x 10^3/kg
C = 0.33 kg CO^2e/kg

CHEESE
6W, 6L, FH, 1F +6C
(+3C fertilizer, +6C cheese production)



The real value of cheese:
W = 5000 liters/kg
L = 1000 m^2 year x 10^3/kg
C = 9.8 kg CO^2e/kg

BASIL
2W, 2L, SH, 2F +1C
(+6C fertilizer, +1C wheat production)

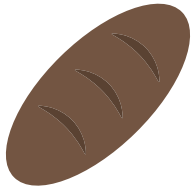
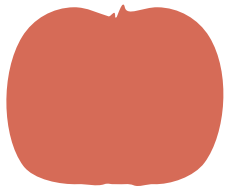
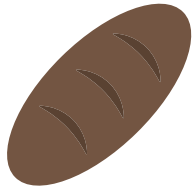
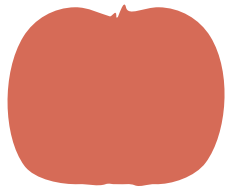
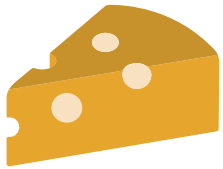
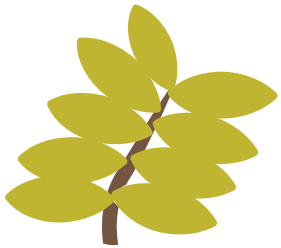
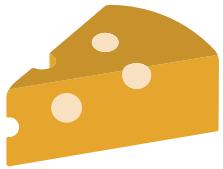
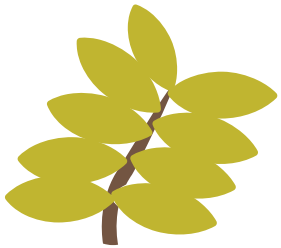


The real value of basil:
W = 180 liters/kg
L = 4 m^2 year x 10^3/kg
C = 0.33 kg CO^2e/kg

Round	Global Funds Used	Solar Carbon Credits	Tree Carbon Credits	Hydro-electric Carbon Credits	Carbon Energy Chips	Profit from Pizzas ($)
1						
2						
Subtotal						
3						
4						
End Total						

LESSON 6: WHERE DOES OUR FOOD COME FROM?

RESOURCES: GAME CARDS (CROP CARDS)

WHEAT 4W, 4L, SH, 1F +5C (+3C fertilizer, +5C wheat production)  The real value of wheat: W = 1300 liters/kg L = 400 km2 year/kg C = 0.65 kg CO2e/kg	TOMATO 2W, 2L, FH, 3F +1C (+9C fertilizer, +1C tomato production)  The real value of tomatoes: W = 180 liters/kg L = 30 km2 year/kg C = 0.33 kg CO2e/kg	WHEAT 4W, 4L, SH, 1F +5C (+3C fertilizer, +5C wheat production)  The real value of wheat: W = 1300 liters/kg L = 400 km2 year/kg C = 0.65 kg CO2e/kg	TOMATO 2W, 2L, FH, 3F +1C (+9C fertilizer, +1C tomato production)  The real value of tomatoes: W = 180 liters/kg L = 30 km2 year/kg C = 0.33 kg CO2e/kg
CHEESE 6W, 6L, FH, 1F +6C (+3C fertilizer, +6C cheese production)  The real value of cheese: W = 5000 liters/kg L = 1000 km2 year/kg C = 9.8 kg CO2e/kg	BASIL 2W, 2L, SH, 2F +1C (+6C fertilizer, +1C wheat production)  The real value of basil: W = 180 liters/kg L = 4 km2 year/kg C = 0.33 kg CO2e/kg	CHEESE 6W, 6L, FH, 1F +6C (+3C fertilizer, +6C cheese production)  The real value of cheese: W = 5000 liters/kg L = 1000 km2 year/kg C = 9.8 kg CO2e/kg	BASIL 2W, 2L, SH, 2F +1C (+6C fertilizer, +1C wheat production)  The real value of basil: W = 180 liters/kg L = 4 km2 year/kg C = 0.33 kg CO2e/kg

LESSON 6: WHERE DOES OUR FOOD COME FROM?

RESOURCES: GAME CARDS (RESOURCE CARDS: FRONT) - PRINT 2-SIDED WITH FOLLOWING PAGE

WATER 	WATER 	RAINWATER 	RAINWATER 	FERTILIZER 	FERTILIZER 
WATER 	WATER 	RAINWATER 	RAINWATER 	FERTILIZER 	FERTILIZER 
LAND 	LAND 	LAND 	LAND 	LAND 	LAND 

RESOURCES: GAME CARDS (RESOURCE CARDS: BACK) - PRINT 2-SIDED WITH PREVIOUS PAGE

FERTILIZER $25 per fertilizer card Player accumulates 3 carbon energy chips for each fertilizer card used to grow crops Only available for purchase during the "Investment" stage	**FERTILIZER** $25 per fertilizer card Player accumulates 3 carbon energy chips for each fertilizer card used to grow crops Only available for purchase during the "Investment" stage	**RAINWATER** Rainwater cards are "free" with the roll of a die during the "Rainy Growing Season" Your food production system can not operate without water Players turn in either "rainwater" or "water" cards to harvest crops	**RAINWATER** Rainwater cards are "free" with the roll of a die during the "Rainy Growing Season" Your food production system can not operate without water Players turn in either "rainwater" or "water" cards to harvest crops	**WATER** $25 for 2 water cards Water cards can be purchased every "Investment" stage, but you must purchase irrigation system first Water cards represent water purchased from water source rather than "free" rainwater that is collected	**WATER** $25 for 2 water cards Water cards can be purchased every "Investment" stage, but you must purchase irrigation system first Water cards represent water purchased from water source rather than "free" rainwater that is collected
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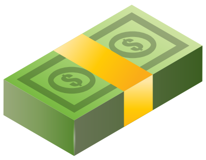
LAND $50 for 1 land unit Each player has 1-6 units of land at the start of the game (based on roll of the die) and can invest in more during "Investment" stage Land is held for the entire game unless players sell land back to Global Bank	**LAND** $50 for 1 land unit Each player has 1-6 units of land at the start of the game (based on roll of the die) and can invest in more during "Investment" stage Land is held for the entire game unless players sell land back to Global Bank	**LAND** $50 for 1 land unit Each player has 1-6 units of land at the start of the game (based on roll of the die) and can invest in more during "Investment" stage Land is held for the entire game unless players sell land back to Global Bank	**LAND** $50 for 1 land unit Each player has 1-6 units of land at the start of the game (based on roll of the die) and can invest in more during "Investment" stage Land is held for the entire game unless players sell land back to Global Bank	**LAND** $50 for 1 land unit Each player has 1-6 units of land at the start of the game (based on roll of the die) and can invest in more during "Investment" stage Land is held for the entire game unless players sell land back to Global Bank	**LAND** $50 for 1 land unit Each player has 1-6 units of land at the start of the game (based on roll of the die) and can invest in more during "Investment" stage Land is held for the entire game unless players sell land back to Global Bank

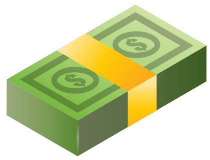
RESOURCES: GLOBAL FUND DOLLARS

GLOBAL FUND DOLLARS



$25

GLOBAL FUND DOLLARS



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GLOBAL FUND DOLLARS

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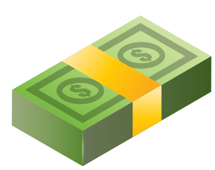

$25

RESOURCES: GLOBAL FUND DOLLARS

GLOBAL FUND DOLLARS

$100

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GLOBAL FUND DOLLARS

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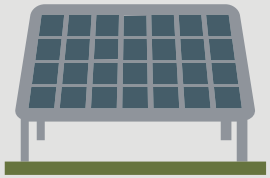
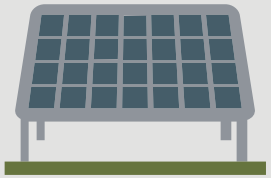
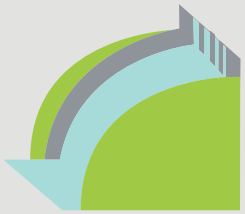
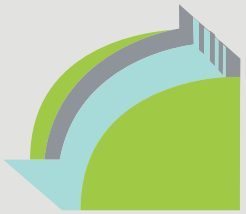
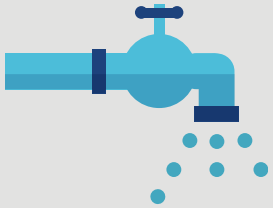
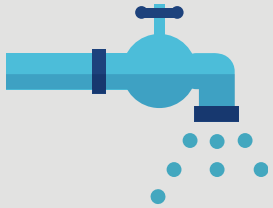
LESSON 6: WHERE DOES OUR FOOD COME FROM?

RESOURCES: GAME CARDS (INVESTMENT CARDS: FRONT) - PRINT 2-SIDED WITH FOLLOWING PAGE

SOLAR	SOLAR	HYDROELECTRIC	HYDROELECTRIC	IRRIGATION SYSTEM	IRRIGATION SYSTEM
					
FISH	FISH	FISH	FISH	PIZZA	PIZZA
					
TREE	TREE	TREE	TREE	AQUAPONIC SYSTEM	AQUAPONIC SYSTEM
					

RESOURCES: GAME CARDS (INVESTMENTCARDS: BACK) - PRINT 2-SIDED WITH PREVIOUS PAGE

IRRIGATION SYSTSEM $100 per system Purchase this system in order to purchase "water" cards Purchase 1 irrigation system card for each crop you want to use water cards for (rather than rainwater). This system stays with the assigned crop throughout the game	**IRRIGATION SYSTSEM** $100 per system Purchase this system in order to purchase "water" cards Purchase 1 irrigation system card for each crop you want to use water cards for (rather than rainwater). This system stays with the assigned crop throughout the game	**HYDROELECTRIC** $100 per card Each system removes 2 carbon energy chips per round 1 land unit required to use this system (space needed to install the system can no longer be farmed)	**HYDROELECTRIC** $100 per card Each system removes 2 carbon energy chips per round 1 land unit required to use this system (space needed to install the system can no longer be farmed)	**SOLAR** $100 per system Each system removes 2 carbon energy chips per round 1 land unit required to use this system (space needed to install the system can no longer be farmed)	**SOLAR** $100 per system Each system removes 2 carbon energy chips per round 1 land unit required to use this system (space needed to install the system can no longer be farmed)
PIZZA Valued at $50 each Can be sold to Global Bank during "production" only Players must turn in 1 of each crop (basil, cheese, wheat, tomato) during production round to make 1 pizza	**PIZZA** Valued at $50 each Can be sold to Global Bank during "production" only Players must turn in 1 of each crop (basil, cheese, wheat, tomato) during production round to make 1 pizza	**FISH** $25 each Must purchase 2 Tilapia (fish) per aquaponic system Fish are the Nitrogen source (fertilizer) for growing crops in aquaponics	**FISH** $25 each Must purchase 2 Tilapia (fish) per aquaponic system Fish are the Nitrogen source (fertilizer) for growing crops in aquaponics	**FISH** $25 each Must purchase 2 Tilapia (fish) per aquaponic system Fish are the Nitrogen source (fertilizer) for growing crops in aquaponics	**FISH** $25 each Must purchase 2 Tilapia (fish) per aquaponic system Fish are the Nitrogen source (fertilizer) for growing crops in aquaponics
AQUAPONIC SYSTEM $100 per system Only grows basil and tomato Reduces water by 50% and removes fertilizer & land requirement (ex: if crop needs 2W, 2L, 3F, player can harvest with just 1W card) Must purchase 2 fish to operate system	**AQUAPONIC SYSTEM** $100 per system Only grows basil and tomato Reduces water by 50% and removes fertilizer & land requirement (ex: if crop needs 2W, 2L, 3F, player can harvest with just 1W card) Must purchase 2 fish to operate system	**TREE** $50 each Each tree removes 2 carbon energy chips each round (growing season) 1 land unit required to plant trees (maximum of 4 trees per land unit)	**TREE** $50 each Each tree removes 2 carbon energy chips each round (growing season) 1 land unit required to plant trees (maximum of 4 trees per land unit)	**TREE** $50 each Each tree removes 2 carbon energy chips each round (growing season) 1 land unit required to plant trees (maximum of 4 trees per land unit)	**TREE** $50 each Each tree removes 2 carbon energy chips each round (growing season) 1 land unit required to plant trees (maximum of 4 trees per land unit)

RESOURCES: GAME CARDS (CRISIS CARDS: FRONT) - PRINT 2-SIDED WITH FOLLOWING PAGE

CRISIS  CARD	CRISIS  CARD	CRISIS  CARD	CRISIS  CARD
CRISIS  CARD	CRISIS  CARD	CRISIS  CARD	CRISIS  CARD

RESOURCES: GAME CARDS (CRISIS CARDS: BACK) - PRINT 2-SIDED WITH PREVIOUS PAGE

CRISIS 5-year drought: You are a California farmer during an El Nino year. Due to this change in weather pattern, a 5-year drought has resulted in a shortage of water **You must lose a water card for every 5 land cards you possess to account for the water shortage for each of the next 2 rounds.** CARD	CRISIS Pestilence: A plague of locusts arrived and devoured one of your crops. **You must forfeit one crop card of your choosing, signifying the destruction of the locust. If you do not have any crop cards, you cannot harvest one of your crops this round.** CARD	CRISIS Electricity shortage: One of the local substations in your area has blown due to a storm and is now under repair. To compensate, you must use your gas-powered generator from the barn to power your systems. **Due to the additional greenhouse gases released, you will receive 5 extra carbon energy chips at the beginning of the next 2 rounds.** CARD	CRISIS Fertilizer shortage: Due to overwheming demand, there is a shortage of fertilizer (causing the price to rise). **When purchasing fertilizer for the next 2 rounds, you must pay $50 per fertilizer card (rather than $25).** CARD
CRISIS Land desertification: A parking lot was placed on the land next to your farm. The parking lot is causing increased heat and evaporation, as well as reduced crop yield. **Before you can purchase more land, you must first mitigate these issues by planting at least 2 trees on 1 piece of land for each of the next 2 rounds.** CARD	CRISIS Flood: You are a farmer just outside of Amarillo, TX that has experienced a prolonged downpour of rain; however, the ground was so dry and hard it couldn't absorb the water. As a result, flash floods moved huge amounts of water over the surface and wiped out part of your farmland. **You must lose 1 crop that was not grown in an aquaponic system or pay $150 for the installation of a tile drainage system for future floods.** CARD	CRISIS Warming temperature: It is an El Nino year in your region. Rainfall is reduced and your land dries out. Due to evaporation, salination of soils starts to set in. Until conditions change, you will have to adapt your system. **You must lose 1 water card and 1 land card for each of the next 2 rounds.** CARD	CRISIS Pollinator crash: Wild honey bee populations are dwindling; therefore your plants are not able to be pollinated. **Before you can harvest more tomatoes, you must pay $100 to the Global Bank to invest in raising your own bee hives on your farm.** CARD

LESSON 7: UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION SUMMIT

THE BIGGER PICTURE

Students conduct a United Nations Food and Agriculture Organization Summit (UN Summit) in order to address the food security challenges they have researched throughout the Food Security module. As a representative of their country, they recommend actions to improve the food production system and follow-up with an individual critical evaluation of the proposed actions. The UN Summit is an authentic, Project Based Learning (PBL) product that incorporates current Next Generation Science Standards (NGSS) and systems thinking. Students will synthesize and apply knowledge and skills acquired in Food Security (FS) Lessons 1-6, and work collaboratively to solve real-world problems.

OBJECTIVES

What students learn

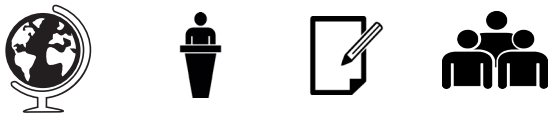
Students learn that a thorough understanding of the complexity of the global food production system is necessary for designing effective solutions to food insecurity. They will learn the importance of negotiation and compromise in reaching consensus in the global community, and the role that the UN plays in addressing international issues. Students also learn how to outline an effective argument, and to support their claims with evidence and logic.

What students do

Students conduct a UN Summit, working collaboratively to come up with practical and realistic solutions to food insecurity in three different countries. They will synthesize information and apply skills learned in FS lessons 1-6, both when outlining major food security challenges as well as when designing their solutions. Finally, they will apply the claim-evidence-reasoning approach in critically evaluating the final four UN Summit Actions developed by the class.

TIME

Part I (50 min) - Defining problem and gathering evidence
Part II (50 min) - Finding solutions and building consensus
Part III (50 min OR homework option) - Testing a solution



STANDARDS

- NGSS PE: HS-LS2-7; DCI: LS2.C; SEP: CEDS; CC: S&C
- NGSS PE: HS- ESS3-4; DCI: ESS3.C; SEP: CEDS; CC: S&C; Influence of ETS
- NGSS PE: HS-ETS1-2; DCI: ETS1.C; SEP: CEDS; CC: Influence of ETS
- NGSS PE: HS-ETS1-3; DCI: ETS1.B; SEP: CEDS; CC: Influence of ETS
- Common Core Science Standards: 1) ELA/Literacy: Integration of Knowledge and Ideas: ELA-LITERACY.RH.11-12.7; 2) Mathematics: MP.2 Reason abstractly and quantitatively (HS-ETS1-1), (HS-ETS1-3), (HS-ETS1-4); 3) Using Mathematics and Computational thinking
- AP Environmental Science standards 11, 16, 17

PREREQUISITES

Student will need their materials from FS Lessons 1-6, and projected water and food import reduction calculations from APPLICATION 1. APES students will also use their population projection and trend calculations. Students should be familiar with with ratios, percentages and proportional relationships.

BEFORE CLASS

Print and read:
PartII UNSummit Systems Thinking Guide Teacher Key
Prepare the following supplies:
Posters: 1 per country group
Post-it notes: 4 per student
Markers: class set
Pull up on computer:
UN Summit overview table (pg. 4 of this document)
UN Overview Video
WRI 2013 - "The Great Balancing Act"
Print 1 copy of the following per student:
Part I_UNSummit_Overview_(Student)
Part I_UNSummit_Gathering Information and Finding Solutions (Student)
Part II_UNSummit_Systems Thinking Guide (Student)
Part III_UNSummit_Testing_A_Solution_(Student)
Part III_UNSummit_Claim_and_Evidence_Rubric_(Student)
Print 1 copy of the following per country group:
PartII_UNSummit_Example_UN Actions_EastFenwick_(Country_Group) (May need to reformat references)
Optional: Example_UN Goals_FAO_Sustainable_Development
WRI(2013)_The_Great_Balancing_Act
Print 1 copy of the following per UN Summit group:
PartII_UNSummit_Grant_for_Proposed_Actions(UNSummit_Group)
Student need to gather these resources from previous lessons in the module:
FS1-FS6: Building Your Case worksheet (handed out during FS1)
APPLICATION 1
FS3: Stakeholder Guiding Questions (Student)
FS3: Stakeholder Table (Student)

TEACHER INSTRUCTIONS

Part 1: Defining the problem, introduction to the United Nations (50 mins)

1. Before class begins, have the students sit with their country groups. Ask them to take out the following resources from previous Food Security module lessons, as they will need them for this class and the remainder of the UN summit: Building Your Case (Student) (handed out during FS1), APPLICATION 1 calculations, Stakeholder Guiding Questions and Stakeholder Table (FS3), and Balancing Act Chart Analysis (Student)(FS5). Then read the following overview of the UN Summit to the class: *"As a result of climate and past land management practices a drought is predicted that cuts agricultural water supplies by 30 percent a year. You as students must practice consensus building to address the crisis, by conducting a UN Food and Agriculture Organization Summit (UNFAO)."*

TEACHER INSTRUCTIONS CONTINUED

1. Continued....*"You will decide as a group to take action for the expansion of growing vegetables to meet the needs of projected population growth over the next 10 years in three countries. As you collaboratively develop ideas as first a country group and then as part of the UN Summit, keep in mind what you have learned throughout the Food Security module about sustainability, different methods of food production, and the complex dynamics of food production systems."*
2. Project the following table for the students, and walk through the plan for the next 3 class periods. Handout a copy of Part I_UNSummit_Overview_(Student) to each student, and tell them to refer to this document as the class moves through the UN Summit.

Day	What students do	What students are asking
Part I: Defining the problem Gathering information	- Learn about the role of the United Nations in world affairs - Country groups conduct research and gather information about the issue of food insecurity in their home country. They then present opening statements to the UN Summit whole group.	- What role could the United Nations play in helping the world solve the problem of food insecurity? - What are the major challenges our country faces around the issue of food security? - What evidence can we provide to most effectively support our claims about the major challenges our country faces around food insecurity?
Part II: Finding solutions Building consensus	- Country groups develop and propose Actions to the UN Summit whole group - Country groups build consensus at the UN Summit to formulate four Actions that will improve food security among the three countries	- How best can the challenges to our country's food security be addressed over the upcoming 10 years, given projected population growth and water shortages? - How and why do our proposed Actions modify the food system and move toward food security? - What evidence can we provide that our country group Actions will be effective? - How can our country group compromise effectively on the international stage to best meet our objectives?
Part III: Testing a solution	- Students compose a critical evaluation letter that supports or argues against the four actions agreed upon at the UN Summit	- What evidence and justification is there for how each Action addresses food insecurity, from the perspective of our stakeholder, in our country?

3. **Say:** "The UN is an international governing body that can help find solutions to complex global problems that manifest locally in unique ways, given differing social, economic, and environmental dynamics. As you watch the following video, take notes in your journal about the role of the UN and ways in which it could help countries achieve greater food security. "
   - Show this introductory video about the UN: UN Overview Video
   - Have students pair-share their thoughts on the above prompts
4. **Direct students** again to their Part I_UNSummit_Overview_(Student) worksheet and review the "Central question for investigation during the UN Summit" and "Additional focus questions" as a class:
   - **Central question:** How would you propose to make your country's food production system more sustainable and less dependent on food imports, if available water was reduced 30% annually due to a predicted 5-year drought across all biomes?
   - **Additional focus questions:** How could you support agricultural expansion to reduce dependency on imports to meet the needs of the population growth of your country over the next 10 years? How could you redirect land and water use to address the 30% reduction of water available for agriculture? Could aquaponics and alternative food growing methods help add stability to the food production system, and reduce environmental impact by cutting greenhouse gas emissions and fertilizer production? Thinking beyond agriculture and recognizing that food security is a systems issue, are there social, political, or economic adjustments that can be made in your country to improve food security?
5. **Say,** "As country groups, you will now develop and present opening statements to the UN body. Your opening statements will serve as an introduction of your country to the UN, with particular focus on the challenges your country faces regarding food security and the specific ways in which drought would impact your food production system." Hand out a copy of Part I_UNSummit_Gathering Information and Finding Solutions (Student) to each student. Direct them to work in country groups for 10-15 minutes to fill in the first column of the "Country Opening Statements" table, using information from their Building Your Case (Student) and any other resources completed earlier in the Food Security module that might prove helpful (see Step 1).
6. Country groups should select one representative to present the opening statement to the class. As presentations unfold, students should take notes in the remaining two columns of their "Country Opening Statements" tables.

Part II: Finding solutions and building consensus (50 mins)

7. **Say,** "Now that we have heard an overview of the major challenges each country faces in addressing food insecurity, each country group will develop and propose a set of four Actions. These proposed Actions will be developed with input from major stakeholders within the country, involved in the issue of food security. In order to persuade other members of the UN summit to adopt your Actions, the Actions should be:" (Ask students to follow along in their Part I_UNSummit_Overview_(Student) handout)
   - Achievable: outline specific steps that can be taken to achieve your action
   - Effective: describe how the action would positively impact different nodes in the food production system, and how such impacts could be quantified
   - Beneficial to as many stakeholders as possible: your Actions will most likely be adopted if you can identify allies within the UN community and if you can demonstrate that the Actions will benefit all three countries

TEACHER INSTRUCTIONS CONTINUED

2. **Hand out a copy** of PartII_UNSummit_Example_UN Actions_EastFenwick_(Country_Group) to each country group, explaining that the document contains an example of Actions proposed to the UN, from the fictitious country of East Fenwick. Encourage students to also look again at their Building Your Case (Student) and "Balancing Act Article Chart Analysis" (FS5) handouts, as well as calculations from APPLICATION 1, as this work can help provide Action ideas.
3. Optional: you can also hand out the original "Great Balancing Act" article (WRI 2013_The_Great_Balancing_Act) and/or Example_UN Goals_FAO_Sustainable_Development as additional resources for the students to review while developing their Actions.
4. **Hand out a copy** of Part II_UNSummit_Systems Thinking Guide (Student) to each student. Within their country groups, have students work individually or in pairs for 15 minutes to complete this worksheet for a particular stakeholder (they can adopt the same stakeholder that they worked with in "FS3: Who Cares? Stakeholders!"). Stakeholder groups should brainstorm 1-2 Actions to propose to their country group, and think through how their Actions will both improve food security given projected drought and population growth, and how their Actions will impact other stakeholders. Encourage students to also think through any opposition their proposed Actions might meet in the international community, and how they might counter this opposition. If students are stuck, see PartII_UNSummit_Systems_Thinking_Guide (Teacher_Key) for prompt ideas.
    - Modifications for varying class sizes: for small class sizes, you can opt for students to all work together as a country group (rather than as stakeholders within a country) to develop their actions. For large class sizes, you can split the class into multiple UN summits or have multiple students work together as a particular stakeholder group.
5. Having completed the "Systems Thinking Guide", all stakeholders within a country group should come together, discuss the Actions formulated by various stakeholders, and choose four to propose to the UN Summit. Allow 20-25 minutes for this step. Students should complete the, "Part II: Finding Solutions - Country Group Action Proposals (student)", which will help them prepare to present their actions to the UN summit. As students discuss and negotiate, circulate and conduct an informal assessment of stakeholder notes, country Action items, and conversation.
6. **Hand out poster paper** and markers to country groups, and direct students to outline their four proposed Actions in poster format. Each country group should choose a representative (someone different from whoever presented the country overview) to present their four Action items to the UN Summit.
7. **Reconvene** the UN Summit for country group Action presentations. Distribute four post-it notes to all UN Summit participants, and tell students that they will be using the post-it notes to vote on what they believe will be the four most effective Action items for all three countries. Check in with the class about the definition of "consensus" - general agreement, or the judgment arrived at by most of those concerned (Merriam-Webster, 2018). Emphasize that while the goal is for the majority of members to agree, the votes may not be unanimous. Encourage students to evaluate Actions from the perspective of their stakeholder, their country as a whole, and as a member of the international community.
8. **Proceed with presentations** and voting on Action items. Appoint a secretary to transcribe the final four Action items into PartII_UNSummit_Grant_for_Proposed_Actions(UNSummit_Group). Each Action item should also include a statement of evidence supporting the effectiveness of the Action.
9. **Formative Exit Ticket:** At the conclusion of the UN Summit, have students reflect in their journals on the following two questions from their personal perspective:
    - Which sub-systems - social, political, economic, environmental, etc - within the food production system do the proposed UN Actions target?
    - Describe three other nodes of the food security system that could be targeted to increase food security, that you feel have not been included in the proposed Actions. How could prioritizing these nodes also prove effective in improving food security?
10. In preparation for Part III, hand out to each student and assign for reading Part III_UNSummit_Testing_A_Solution_(Student) and Part III_UNSummit_Claim_and_Evidence_Rubric_(Student).

Part III: Testing a solution (50 mins or homework)

11. **Ask students** to follow along in their PartIII_UNSummit_Testing_A_Solution_(Student) handout as you introduce the assignment: "As a group the UN Summit deliberated on a set of four Actions that, when funded, can change food production systems to help improve security. As stakeholders in your country, you must now evaluate these Actions. Your critical evaluation of these Actions will demonstrate your learning and systems thinking skills. Your central question is: Will the four Actions adopted by the UN Summit improve food security for your country, given projected population growth and a 30% decrease in the available water supply?"
12. **Walk through** the remainder of the handout guidelines with the class, reminding students of the 3 pillars of food security, explaining the claim-evidence-reasoning structure that you are asking them to follow, and encouraging them to refer to previous assignments from the Food Security module when collecting evidence to support their claims. Emphasize that they are taking a stand on the effectiveness of the Actions in their home country and from the perspective of their stakeholder.
13. **Ask students** to take out their copy of Part III_UNSummit_Claim_and_Evidence_Rubric_(Student) if they haven't already, and summarize how you will evaluate their letters based on how successfully they support their claims with evidence and logically argue their position.
14. Allow the remainder of the class for students to complete their letters, and assign the remainder for homework if necessary.

LESSON 7: UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION SUMMIT

RESOURCES

- UN Video Overview
- WRI 2013 - "The Great Balancing Act"
- PartII_UNSummit_Systems_Thinking_Guide (Teacher_Key)
- Part I_UNSummit_Overview_(Student)
- Part I_UNSummit_Gathering Information and Finding Solutions (Student)
- Part II_UNSummit_Systems Thinking Guide (Student)
- Part III_UNSummit_Testing_A_Solution_(Student)
- Part III_UNSummit_Claim_and_Evidence_Rubric_(Student)
- PartII_UNSummit_Example_UN Actions_EastFenwick_(Country_Group)
- Example_UN Goals_FAO_Sustainable_Development
- PartII_UNSummit_Grant_for_Proposed_Actions (UNSummit_Group)
- Part II: Finding Solutions - Country Group Action Proposals (student)
- FS1-FS6: Building Your Case (Student) (handed out during FS1)
- APPLICATION 1
- FS3: Stakeholder Guiding Questions (Student)
- FS3: Stakeholder Table (Student)
- FS5: Balancing Act Chart Analysis (Student)

RESOURCES - Not required, but additional information if interested

- http://www.fao.org/faostat/en/#country (demographic, economic, political, environmental, and food production statistics on each country, from the FAO)
- http://www.globalhungerindex.org/results-2017/ (current reports on worldwide hunger and undernutrition)

Case Study: Haiti

- http://www.fao.org/faostat/en/#country/93 (FAO statistics for Haiti)
- http://www.greenfacts.org/en/water-resources/figtableboxes/aquastat79.htm (Water availability in Haiti)
- http://www.iadb.org/en/news/webstories/2013-03-04/irrigation-in-haitis-artibonite,10333.html (Example of an aid initiative to train local farmers on more effective agricultural techniques)
- http://pdf.usaid.gov/pdf_docs/Pnach663.pdf (Case Study USAID Haiti)
- http://www.ifpri.org/news-release/2013-global-hunger-index-country-case-study-haiti (International Food Policy Research case study)
- http://humanitarian.worldconcern.org/2013/04/17/food-insecurity-the-silent-crisis-in-haiti/ (challenges facing small farmers in Haiti, and a potential solution)
- http://www.foodsecurityportal.org/haiti (food security indicators, including GNI and measurements of exports and imports)
- http://www.genderaction.org/publications/fdsec/haiti.pdf (emphasizes the importance of considering gender equity in projects funded by international development investing in Haiti)

Case Study: North Korea

- http://www.fao.org/faostat/en/#country/116 (FAO statistics for North Korea)
- http://www.greenfacts.org/en/water-resources/figtableboxes/aquastat96.htm (Water availability in North Korea)
- http://www.fao.org/news/story/en/item/412030/icode/ (FAO, impact of drought on food production in North Korea)
- http://www.fao.org/emergencies/countries/detail/en/c/161543/ (FAO initiatives in North Korea to improve food security)
- https://www.npr.org/sections/goatsandsoda/2018/06/19/620484758/the-food-insecurity-of-north-korea (impact of politics on food security)
- http://www.miseast.org/en/nkorea/food-insecurity-north-korea (aid organization's overview of factors contributing to food insecurity in North Korea)
- https://www.brookings.edu/opinions/world-food-day-the-challenge-of-north-korea/ (political, economic, and social factors contributing to food insecurity in North Korea)

Case Study: Namibia

- http://www.fao.org/faostat/en/#country/147 (FAO statistics for Namibia)
- http://www.greenfacts.org/en/water-resources/figtableboxes/aquastat123.htm (Water availability in Namibia)
- http://www.un.org.na/home_htm_files/ZHRM.pdf ("Namibia Zero Hunger Roadmap" - outlines initiatives to eliminate hunger in Namibia 2016-2020)
- http://www.orangesenqurak.com/challenge.aspx (overview of water use and management in the Orange-Senqu River Basin, the main source of fresh water in Namibia)
- http://www.the-eis.com/data/literature/UNDP%20Adapting%20to%20climate%20change_2012.pdf (report on UNDP project to improve adaptive capacities of natural resource users in preparation for drought related to climate change)
- http://www1.wfp.org/countries/namibia (The World Food Program on hunger in Namibia)
- https://www.usnews.com/news/best-countries/articles/2017-12-29/africa-hunger-initiatives-bearing-some-fruit (Article on successful agricultural initiatives in various African countries)
- https://borgenproject.org/hunger-in-namibia/ (Outlines structural and environmental causes of hunger in Namibia, and provides links to government development initiatives)

LESSON 7: UNITED NATIONS FOOD AND AGRICULTURE ORGANIZATION SUMMIT

RESOURCES: PART I UNSUMMIT_OVERVIEW_(STUDENT)

UN Summit Overview:

At the UN Summit, three countries will gather to propose Actions that will help overcome food security challenges, given projected population growth and a reduction in water supply due to drought. Stakeholders representing each country will offer their expertise and perspective in helping to shape these global initiatives. Using country-specific data generated earlier in the Food Security module, participants will provide supporting evidence and apply systems thinking to help solve a complex, real-world problem that involves economic, political, social, and environmental systems. How can the UN help these countries produce and manage local resources in an environmentally sustainable fashion that will help them meet the future nutritional needs of their respective populations?

Schedule: 3 x 50 min class periods

Day	What students do	What students are asking
Part I: Defining the problem Gathering information	- Learn about the role of the United Nations in world affairs - Country groups conduct research and gather information about the issue of food insecurity in their home country. They then present opening statements to the UN Summit whole group.	- What role could the United Nations play in helping the world solve the problem of food insecurity? - What are the major challenges our country faces around the issue of food security? - What evidence can we provide to most effectively support our claims about the major challenges our country faces around food insecurity?
Part II: Finding solutions Building consensus	- Country groups develop and propose Actions to the UN Summit whole group - Country groups build consensus at the UN Summit to formulate four Actions that will improve food security among the three countries	- How best can the challenges to our country's food security be addressed over the upcoming 10 years, given projected population growth and water shortages? - How and why do our proposed Actions modify the food system and move toward food security? - What evidence can we provide that our country group Actions will be effective? - How can our country group compromise effectively on the international stage to best meet our objectives?
Part III: Testing a solution	- Students compose a critical evaluation letter that supports or argues against the four actions agreed upon at the UN Summit	- What evidence and justification is there for how each Action addresses food insecurity, from the perspective of our stakeholder, in our country?

Central question for investigation during the UN Summit:

- How would you propose to make your country more food secure, if available water resources are reduced by 30% annually due to a predicted 5-year period of drought across all biomes?

Additional focus questions:

- How could you support agricultural expansion to reduce dependency on imports to meet the needs of the population growth of your country over the next 10 years?
- How could you redirect land and water use to address the 30% reduction of water available for agriculture?
- Could aquaponics and alternative food growing methods help add stability to the food production system, and reduce environmental impact by cutting greenhouse gas emissions and fertilizer production?
- Thinking beyond agriculture and recognizing that food security is a systems issue, are there social, political, or economic adjustments that can be made in your country to improve food security?

PART 1: DEFINING THE PROBLEM

1. As a country group, you will first prepare an opening statement. Your opening statements will serve as an introduction of your country to the UN, with particular focus on the challenges your country faces regarding food security and the specific ways in which drought would impact your food production system.
2. Have the following materials from previous lessons on hand to help you gather the information necessary for your opening statement, as well as the work you will be doing in Part II and III:
   - FS1-FS6: Building Your Case (Student) (handed out during FS1)
   - APPLICATION 1
   - Stakeholder Guiding Questions and Stakeholder Table (FS3)
   - FS5: Balancing Act Chart Analysis (Student)
3. Fill out the first column in "Country Opening Statements" table in the handout, Part I_UNSummit_Gathering Information and Finding Solutions (Student), using the questions to guide you as you prepare your statement.
4. As other country groups present their statements, listen critically and record evidence in the remaining columns of the "Country Opening Statements" table.

RESOURCES: PART I UNSUMMIT_OVERVIEW_(STUDENT) CONTINUED

PART II: FINDING SOLUTIONS AND BUILDING CONSENSUS

5. Each country group will develop and propose a set of four Actions to address the issue of food insecurity in all three countries. These proposed Actions will be developed with input from major stakeholders within your country, involved in the issue of food security. In order to persuade other members of the UN summit to adopt your Actions, the Actions should be:
   - Achievable: outline specific steps that can be taken to achieve your action
   - Effective: describe how the action would positively impact different nodes in the food production system, and how such impacts could be quantified
   - Beneficial to as many stakeholders as possible: your Actions will most likely be adopted if you can identify allies within the UN community and if you can demonstrate that the Actions will benefit all three countries
6. Refer to the handout, PartII_UNSummit_Example_UN Actions_EastFenwick_(Country_Group), to see examples of of Actions proposed to the UN, from the fictitious country of East Fenwick.
7. Either individually or in pairs, select a stakeholder group within your country group and complete the Part II_UNSummit_Systems Thinking Guide (Student) handout from the perspective of your stakeholder. Your goal is to brainstorm 1-2 Actions to propose to your country group, and think through how these Actions will both improve food security given projected drought and population growth, and how these Actions will impact other stakeholders. Additionally, try and predict any opposition that your proposed Actions might meet in the international community, and strategize about how you might counter this opposition.
8. Rejoin your country group, and discuss your proposed Actions with the other stakeholders. Together you will now complete "Part II: Finding Solutions - Country Group Action Proposals", starting on pg. 2 of your Part I_UNSummit_Gathering Information and Finding Solutions (Student) handout. Use the poster paper and markers provided to write up the final four Actions that your country group agrees upon.
9. Select two country representatives to present the four proposed Actions to the whole UN Summit group. All other members listen and record notes using the final table on the Part I_UNSummit_Gathering Information and Finding Solutions (Student) handout.
10. Await further directions from the teacher.

PART III: TESTING A SOLUTION

11. In this portion of the lesson, you will critically evaluate each of the four Actions adopted by the UN Summit, from the perspective of the stakeholder you represented in Part II. Refer to your PartIII_UNSummit_Testing_A_Solution_(Student) and Part III_UNSummit_Claim_and_Evidence_Rubric_(Student) handouts for detailed instructions.

Congratulations!
You have significantly contributed to improving global food security through your detailed research, analysis, clear logic, and cooperation and negotiation at the UN Summit.

RESOURCES: PART I: GATHERING INFORMATION AND FINDING SOLUTIONS (STUDENT)

UN Summit Country small group: _____

Use the first column of this table to describe the status of food security in your country. One representative from each country will use this information to present an opening statement about your country to the UN Summit. As the other two country groups are presenting, take notes in the remaining two columns about their state of food security.

TABLE: Country Opening Statements - Outlining Food Security at the National Level

Defining the Problem	Country _____	Country _____	Country _____
What are the three most important problems overall this country faces?			
Describe any challenges the country already faces specifically related to food security and water shortage.			
What is the current water usage for agriculture? Where do they get water for agriculture?			
How would the country be impacted by a 30% reduction in agricultural water supply due to a drought? Are there backup water resources available?			
What are some constraints you would face in trying to improve food security in this country?			
Is there any other information about this country (e.g. political, social, economic) that would be helpful to know in determining how best to address food insecurity and drought?			

Additional notes:

Is there any additional information about your country that would be helpful to present in your opening statement that you haven't already researched in previous lessons of the food security module (other calculations, environmental conditions, limits to resources, methods of growing food, etc)?

RESOURCES: PART II: UN SUMMIT - EXAMPLE UN ACTION, EAST FENWICK (COUNTRY GROUP HANDOUT)

Here are example recommendations for actions that the country of East Fenwick has proposed, which include many potential solutions working in tandem:

Sustainable management of land resources must become a central task for East Fenwick politicians at a local and national level. In response to Agenda 21, the government created the Council for Sustainable Development (CSD). CSD paved the way for democratic forest management, where forest governance, legal authority, and institutional management should be transferred to rural groups to protect natural forest.

1. In response to hunger riots, the country proposed subsidised staples (e.g. bread) and reduced customs duties on food imports. The country also drastically limited their exportation of staples in order to feed their own population (Braun 2016, 5).

2. During the food crisis: the country was proposed 1.3 million purchase of millions of hectares of land in nations with a high degree of food insecurity by another wealthy country. (Grain 2008). This set off demonstrations and led to the ousting of the President of East Fenwick in March 2016. *

3. The country proposed The World Food Programme (WFP) to offset the rising cost of food with USD $500 million. Due to the 40% increase in food commodity prices during a year, WFP either had to cut the number of beneficiaries by 40% or had to raise more funds. *

4. Requested Switzerland CHF donate $20 million for multilateral research in agriculture oriented towards small farmers. The programme has three objectives: reinforcing access to food for the most vulnerable, guaranteeing access to land and to natural resources for smallholders and improving access to know-how, technology and farming input so as to enable small farmers to boost productivity in a sustainable manner. 17

5. The Alliance for a Green Revolution in East Fenwick (AGREF). Created by East Fenwick organisations and chaired by Kofi Annan, former UN Secretary-General, this alliance has received support from the Rockefeller Foundation and the Bill and Melinda Gates Foundation (BMGF). It can support agricultural research centres in universities and businesses. 18 Its objectives are to improve seeds, fortify the soil, make water and markets more accessible, develop agriculture know-how and back policies in favour of smallholders.

6. Via Campesina has gone even further by proposing the recognition of new rights for smallholder farmers. This movement brings together more than 140 peasant organisations from nearly 70 countries and represents more than 200 million peasants. It adopted the Declaration on the Rights of Peasants: Women and Men21 and then submitted it to the UN as a solution to both the food crisis and chronic undernourishment (Gollam 2016c).

*Source: "The Food Crisis and Food Security: Towards a New World Food Order" by Christophe GOLAY p. 215-232 The Graduate Institute Geneva, 2010 https://poldev.revues.org/145

Here are samples of earlier proposals to GUIDELINES for sustainable development. (Note: not all of these goals apply directly to individual countries and their food growing system).

From Sustainable Development Goals of the UNFAO Open Working Group from 1-2-15 (https://sustainabledevelopment.un.org/processes/post2015/owg/proposal)

Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

2.1: By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations including infants, to safe, nutritious and sufficient food all year round.

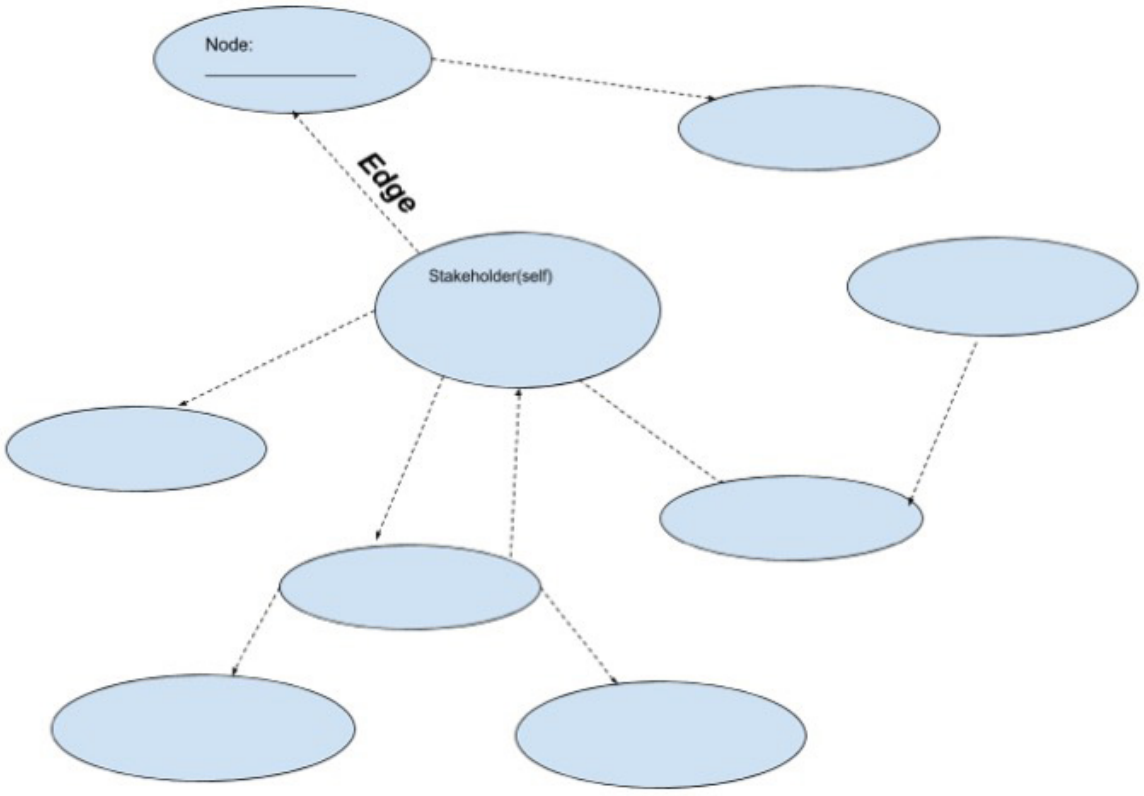
2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters, and that progressively improve land and soil quality.

2.5: By 2020, maintain genetic diversity of seeds, cultivated plants, farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at national, regional and international levels, and ensure access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge.

RESOURCES: PART II: UNSUMMIT_SYSTEMS THINKING GUIDE (STUDENT)

Directions:

From the perspective of your stakeholder group, come up with two or more UN Actions that you will propose to your country group. Begin by using the food security causal loop systems diagram below to refresh your memory from "Lesson 3: Stakeholders! Who Cares?" and "Lesson 4: Food Security as a System" about how your stakeholder group is connected to other stakeholders within the food security system. Recall that the circles/nodes represent the stakeholders in the system, and the arrows/edges represent the relationships between stakeholders. Your "Stakeholder Guiding Questions" and "Stakeholder Table" from Lesson 3 will help you complete this task. Then, try and formulate Actions that will benefit as many other stakeholders as possible, keeping in mind that the aim of these Actions is to improve food security in all three countries. The "Balancing Act Article Chart Analysis" handout from Lesson 5 can help provide Action ideas.



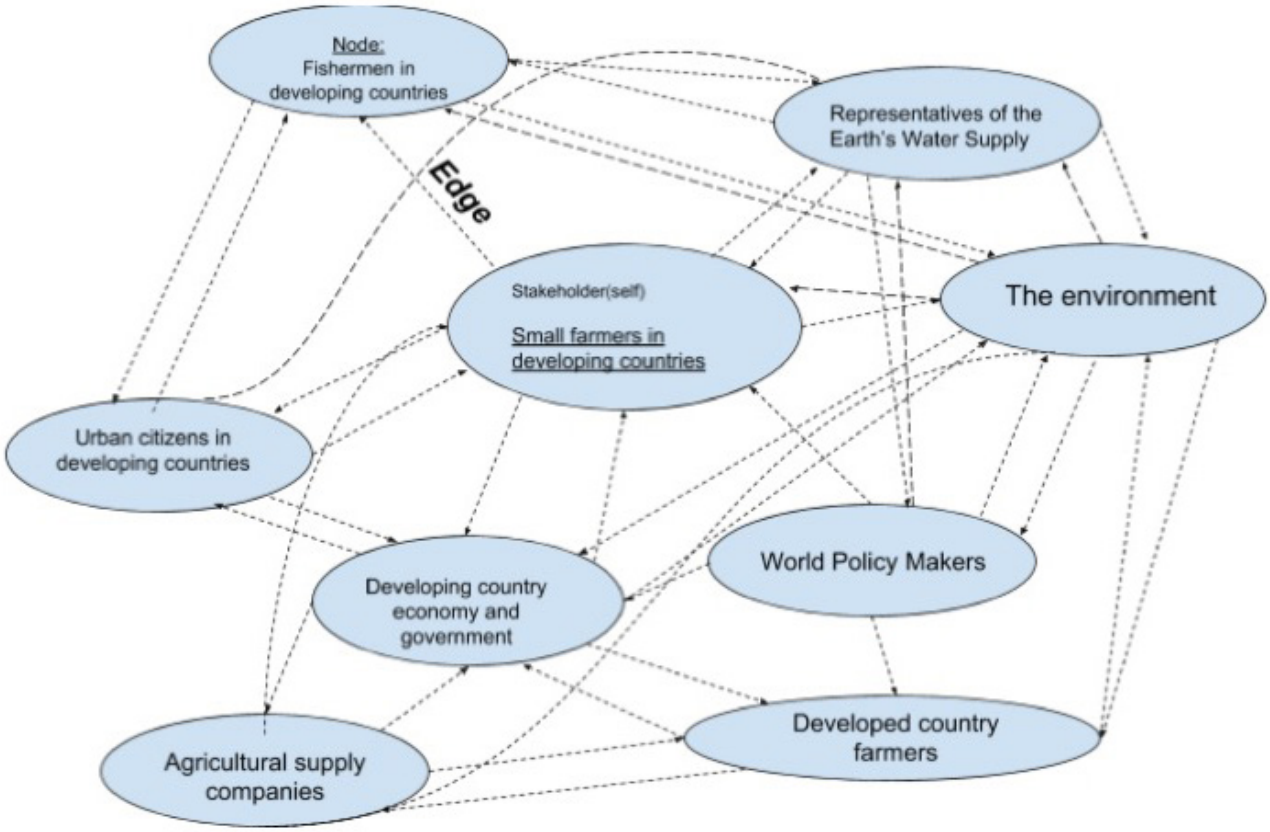
RESOURCES: PART II: UN SUMMIT _SYSTEMS THINKING GUIDE (STUDENT) Stakeholder Group _____

Ideas for UN Actions (proposed solutions) that would be beneficial from the perspective of your stakeholder group	How would the Action you proposed improve food security in your country?	Which other systems nodes/stakeholders would be positively affected by your Action?	Which other systems nodes/stakeholders would be negatively affected by your Action?	Can you think of any unintended consequences your Action might have on the system?	How do you foresee your Action being received by the international community?

RESOURCES: PART II: UNSUMMIT_SYSTEMS THINKING GUIDE (TEACHER KEY)

Directions:

From the perspective of your stakeholder group, come up with two or more UN Actions that you will propose to your country group. Begin by using the food security causal loop systems diagram below to refresh your memory from "Lesson 3: Stakeholders! Who Cares?" and "Lesson 4: Food Security as a System" about how your stakeholder group is connected to other stakeholders within the food security system. Recall that the circles/nodes represent the stakeholders in the system, and the arrows/edges represent the relationships between stakeholders. Your "Stakeholder Guiding Questions" and "Stakeholder Table" from Lesson 3 will help you complete this task. Then, try and formulate Actions that will benefit as many other stakeholders as possible, keeping in mind that the aim of these Actions is to improve food security in all three countries. The "Balancing Act Article Chart Analysis" handout from Lesson 5 can help provide Action ideas.



RESOURCES: PART II: UN SUMMIT _SYSTEMS THINKING GUIDE (TEACHER KEY)

For the teacher: in the table below, we list one Action for each of the stakeholder groups, and suggest different Actions for each group to provide a variety of ideas. Some of the actions can be proposed by several of the stakeholder groups, while some may not be applicable to certain case study countries.

Stakeholders	Ideas for UN Actions (proposed solutions) that would be beneficial from the perspective of your stakeholder group	How would the Action you proposed improve food security in your country?	Which other systems nodes/stakeholders would be positively affected by your Action?	Which other systems nodes/ stakeholders would be negatively affected by your Action?	Can you think of any unintended consequences your Action might have on the system?	How do you foresee your Action being received by the international community?
Small farmers in developing countries	Higher tariffs on imported food	Increase demand for local produce and economically support small farmers	The environment - reduced GHGs due to transportation of produce, reduced packaging materials	International agribusiness	Increased food prices, decreasing food security for those who can't afford the rise in price	Both positive and negative reactions, depending on whether a country imports or exports agricultural products, and whether or not they feel they can be self-sufficient in terms of food production
Fishermen in developing countries	Implementation of marine protected areas, with exclusive fishing rights surrounding them granted to local fisherfolk	Marine protected areas prevent the collapse of local fisheries and improve yields along their boundaries	The environment, urban citizens in developing countries	Fishermen in developed countries who might be employed by international businesses that fish off developing country coastlines	Initial decreased catch (and food insecurity) due to local fishing areas being relegated to marine protected area status	Positively by those stakeholders with a long-term perspective on food security, negatively by countries with international fishing fleets
Urban citizens in developing countries	Funding for public education and job-related training programs	Higher education enables individuals to obtain higher-paying jobs, which provide more income available for food expenditures	Developing country economy, small farmers and fishermen in developing countries	None really. A stretch would be that low-income families often rely on the labor of their children, so might suffer initially as their children spend time in school rather than in the labor market.	Developing countries often experience "brain drain" when educated citizens emigrate in search of better opportunities overseas	Positively
Developing country economy and government	Funding for implementation of improved irrigation systems	By reducing reliance of farmers on rainfall, irrigation technology helps mitigate the adverse impact of drought on agricultural production.	Small farmers and urban citizens in developing countries	Poorly planned irrigation systems could harm the environment	Over-use and drainage of groundwater supplies, re-routing of funds into the pockets of corrupt politicians	Positively, but with some skepticism from representatives of the Earth's water supplies
Representatives of developed country farmers	Subsidies to promote organic farming methods and more biodiverse crops	Improved land management and reduced fertilizer use will sustain higher crop yields and reduce impacts on downstream water supplies, where fishing occurs.	The environment, developed country citizens (food consumers)	Agricultural supply companies, because changes in farming methods would most likely decrease demand for synthetic fertilizers and genetically modified seeds	Movement away from monocultures might initially decrease the supply of staple food crops	A mixed reception. World policy makers (concerned about bulk food supply) and representatives of developed country economies (which supply products needed to sustain monocultures) might resist this action.

LESSON 6: WHERE DOES OUR FOOD COME FROM?

RESOURCES: PART II: UN SUMMIT _SYSTEMS THINKING GUIDE (TEACHER KEY)

For the teacher: in the table below, we list one Action for each of the stakeholder groups, and suggest different Actions for each group to provide a variety of ideas. Some of the actions can be proposed by several of the stakeholder groups, while some may not be applicable to certain case study countries.

Stakeholders	Ideas for UN Actions (proposed solutions) that would be beneficial from the perspective of your stakeholder group	How would the Action you proposed improve food security in your country?	Which other systems nodes/stakeholders would be positively affected by your Action?	Which other systems nodes/stakeholders would be negatively affected by your Action?	Can you think of any unintended consequences your Action might have on the system?	How do you foresee your Action being received by the international community?
Energy companies	Support for research and development of sources of alternative energy (solar, wind, geothermal)	Reductions in greenhouse gas emissions will slow the rate of climate change, which can cause devastation to agricultural productivity (e.g. tropical storms, drought, rising sea level)	The environment, representatives of the Earth's water supply, EVERYONE	Possibly representatives of food transport companies, who might deny the necessity of switching away from fossil fuels given the difficulty and expense of transitioning to transportation vehicles that run on alternative fuels	Down the road, economies reliant on fossil fuel exports (e.g. Venezuela, Saudi Arabia) will falter as alternative energy sources are adopted, and food insecurity may increase in those areas. Alternative energy sources can also have environmental consequences, such as bird mortality on wind farms and impacts on downstream habitat after dam construction.	A mixed reception, with likely some resistance from food transport companies, big agribusiness, and governments that do not fully accept the scientific evidence behind climate change
Agricultural supply companies	Support for research and development of improved seed varieties, and seed libraries to preserve knowledge of native plant species	Developing seed varieties adapted to drought and other climate variations resulting from global warming will ensure harvests even under challenging environmental conditions. Seed libraries can provide the fodder for developing these improved varieties	Citizens of developed and developing countries, possibly the environment (depending on whether or not genetic modification is used), the Earth's water supply	Possibly small farmers, if access to improved seed varieties is controlled by agribusiness	If seeds are genetically modified, the adult plants can cross-pollinate with neighboring organic crops and produce seedless plants, resulting in increased reliance of local farmers on agribusiness for their seed supply.	Positively, as long as public access to seed banks is ensured
Representatives of food transport companies	Support research and development of technologies that improve the lifespan of produce	Areas unable to produce their own food due to adverse environmental conditions could still have access to relatively fresh fruit and vegetables	Developed and developing country citizens, developed and developing country economies, Earth's water supply	The environment (action does not address the consequences of fossil fuel use in produce transportation)	Maintains the status quo regarding demand for agricultural products far from where it is produced	Positively, although small farmers may resist
Developed country citizens	More stringent regulations regarding food labeling, with emphasis on the environmental impact of the production process	Citizens will be better informed as to how their food is produced, and can choose food produced in a more sustainable fashion, encouraging positive stewardship of the environment	The environment, representatives of the Earth's water supply, fishermen and farmers who produce food sustainably	Representatives of developed country farmers, representatives of a developed country economy	If not appropriately regulated, inaccurate food labeling can mislead consumers. Also, farmers reliant on unsustainable methods of farming will go out of business	A mixed reception - representatives of developed country economies and farmers might argue that this action will drain the resources of food producers

RESOURCES: PART II: UN SUMMIT _SYSTEMS THINKING GUIDE (TEACHER KEY)

For the teacher: in the table below, we list one Action for each of the stakeholder groups, and suggest different Actions for each group to provide a variety of ideas. Some of the actions can be proposed by several of the stakeholder groups, while some may not be applicable to certain case study countries.

Stakeholders	Ideas for UN Actions (proposed solutions) that would be beneficial from the perspective of your stakeholder group	How would the Action you proposed improve food security in your country?	Which other systems nodes/stakeholders would be positively affected by your Action?	Which other systems nodes/ stakeholders would be negatively affected by your Action?	Can you think of any unintended consequences your Action might have on the system?	How do you foresee your Action being received by the international community?
World policy makers (e.g. FAO, UNDP)	Provision of equipment and training to local farmers to mitigate the impact of drought	Build resilience of local farmers to environmental shocks and stabilize food production	Farmers (both in developed and developing countries), representations of the Earth's water supply, the environment, citizens	Possibly energy companies, as farmers learn more efficient methods of providing their crops with water; citizens may experience reduced choice regarding plant products if drought-resistant species adapted to local environments are encouraged	Ideas about effective equipment and farming methods coming from international policy makers may pull local farmers away from traditional farming methods suited to their local geography	Positively
Representatives from the World Health Organization	Improve girls' education and access to reproductive services to achieve a replacement fertility rate of 2.1	Women can provide better nourishment to fewer children, and education also enables them to help raise their family's socioeconomic status (greater disposable income can be spent on food products)	Citizens of developing countries, including small farmers, fishermen, and urban dwellers	Male heads of households may be opposed to the empowerment of women in their families, and their voice might be echoed in representatives of their country's economy and government	This intervention could disrupt traditional cultures	Positively overall, with resistance from paternalistic societies opposed to uplifting women
The environment	Improve soil management techniques (e.g. biological nitrogen fixation, crop rotation, cover cropping) through farmer-training programs	Food production per unit land area can be increased with intelligent and sustainable soil management techniques. Improved soil management will also prevent erosion, salinization, and desertification, processes that render agricultural land unproductive	Citizens and farmers in both developed and developing countries, national economies	Possibly agricultural supply companies, as fertilizer use becomes more efficient	This funding may go to waste if government subsidies that encourage planting crops ill-suited to their environment continue. Various cover crop species could spread uncontrollably as alien invasives if local species are not utilized. Watershed health will improve as fertilizer runoff decreases.	Positively overall, with potentially some resistance from big agribusiness
Representatives of the Earth's water supply	Upscale aquaponics systems	Greater agricultural productivity per unit of water use, increased protein supply, reduced reliance on synthetic fertilizers	The environment, energy companies, agricultural supply companies (aquaponics equipment)	Agricultural supply companies (fertilizer), fisherfolk	Increased greenhouse gas emissions if electricity is not sustainably generated	Positively

RESOURCES: PART II: FINDING SOLUTIONS - COUNTRY GROUP ACTION PROPOSALS (STUDENT)

Directions: Having completed the "Systems Thinking Guide", all stakeholders within a country group should come together, discuss the Actions formulated by various stakeholders, and choose four to propose to the UN Summit. Complete the sections below to guide you in preparing to present to the summit.

1. State the four actions you propose will address the problem of global food insecurity, with particular emphasis on the three countries represented at the UN Summit:

2. Explain how the Actions you proposed will improve food security in these three countries given the predicted drought.

3. What evidence do you have that your Actions will be effective? Use your research from previous lessons to justify the proposal of each Action.

4. In the space below, sketch a systems diagram to predict and trace the positive effects your actions will have on the food production system. You are encouraged to use different colors to represent the effects of the four different Actions. What are the social, economic, political, and environmental nodes within the food production system that these UN Actions will target?

RESOURCES: PART II: FINDING SOLUTIONS - COUNTRY GROUP ACTION PROPOSALS (STUDENT)

5. Finally, summarize your plan in the table below and use it to help present your Actions to the UN Summit.

Proposed Action(s)	Problems addressed (specific to the countries attending)	Predicted positive outcomes	Supporting evidence

6. NOTES on Actions proposed by other countries:

Country proposing	Proposed Action	Notes

RESOURCES: PART II: UNSUMMIT_GRANT_FOR_PROPOSED_ACTIONS (UNSUMMIT_GROUP)

1 per UN Summit, to be completed by the appointed UN secretary

In principle, UNFAO combined total funds of $1,000,000 will be allocated for projects and actions to support guidelines with default duration of two years. Grants will not necessarily match the full amounts applied for. Grant allocations will not exceed US$400,000 for any given project, and will be of a minimum of US$50,000. Applicants must request an amount within this range. The majority of projects are granted no more than $250,000. Once the implementation period has elapsed, beneficiaries will be required to return unspent funding to UNFAO. Examples from the fictional country of East Fenwick can be found here.

United Nations Food and Agriculture Organization Fund
Project Proposal Summary

Be it resolved that:

Article 1: The UNFAO will take action to provide ...

Article 2: The UNFAO will take action to provide ...

Article 3: The UNFAO will take action to provide ….

Article 4: The UNFAO will take action to provide ...

RESOURCES: PART III: UN SUMMIT - TESTING_A_SOLUTION (STUDENT)

The Assignment:

As a group the UN Summit deliberated on a set of four Actions that, when funded, can change food production systems to help improve security. As stakeholders in your country, you must now evaluate these Actions. Your critical evaluation of these Actions will demonstrate your learning and systems thinking skills. Your central question is: Will the four Actions adopted by the UN Summit improve food security for your country, given projected population growth and a 30% decrease in the available water supply?

You will answer this question in the form of a letter to the UN Food and Agriculture Organization. In this letter, be sure to do the following:

1. Write from the perspective of the country stakeholder you represented during the UN Summit, and assess the effectiveness of the Action for your country

2. Address the 3 pillars of food security: will food in your country be more available, more accessible, and used more effectively?

3. Evaluate each of the four UN Summit Actions using the Claim-Evidence-Reasoning approach. Your letter should either:
   - Make a claim on behalf of your country, supporting the proposed Actions and providing evidence and reasoning as to why each Action will positively affect food security.

     OR
   - Make a claim on behalf of your country, requesting specific changes to the proposed Actions and providing evidence and reasoning as to why you believe the Actions will prove ineffective in your country and why your suggested changes will better improve food security.

4. Answer these sub-questions:
   - What will the effects of the Actions be on food production efficiency, and your country's dependence on food imports?
   - Will the Actions create a more environmentally sustainable food production system? Consider fertilizer production and use, water resources, and greenhouse gas emissions in your answer.
   - How effectively will the actions address the predicted 30% decrease in available water supply?

5. Use scientific evidence, and preferably quantitative data, to support your claims. As you did when coming up with Actions to propose at the UN Summit, consider these resources that you have developed throughout the module:
   - Calculations from APPLICATION 1, estimating water and food import savings from a model aquaponics model system
   - Population growth and other country data from the "Building Your Case" worksheet (Lesson FS1)
   - Systems network diagrams nodes and edges from Lesson FS4 and UN Summit work
   - "The Great Balancing Act" and your "Balancing Act Article Chart Analysis" from Lesson FS5

6. Refer to the "Part III: UN Summit - Claim and Evidence Writing Rubric" handout that you received along with these guidelines for specifics on how your letter will be graded.

Take a stand! Again, your question is:
Combined, can the four adopted UN Summit Actions significantly improve food security in your country given projected drought and population growth?

RESOURCES: PART III: UNSUMMIT _CLAIM_AND_EVIDENCE_RUBRIC (STUDENT)

"Testing a Solution" Essay Assignment

	4 points	3 points	2 points	1 point
Claim: A correct and complete statement that responds to the question asked or the problem posed.	Claim is: • Clear • Correct (in the context of their data) • Logical • Detailed • Linked to investigative question	The claim is correct (in the context of their data) but is missing one of the aspects below: • Clear • Logical • Detailed • Linked to investigative question	The claim is missing two or more of the aspects below: • Clear • Correct (in the context of their data) • Logical • Detailed • Linked to investigative question	Student has made a claim; however, it is not understandable.
Evidence: Convincing, appropriate and sufficient data and observations that support the claim.	Only the most convincing data (most likely a calculation to summarize data) are used to support the claim. There is sufficient evidence to support their findings. Evidence makes a comparison to relevant groups (including control group) when appropriate.	Convincing data is used to support the claim (most likely a calculation to summarize data) Data may not be the most convincing or may be extraneous. There is sufficient evidence to support findings. Evidence makes a comparison to relevant groups (including control group) when appropriate.	Relevant data is used to support the claim; however, the data are not convincing, may lack calculations, or may include extraneous data. There is not sufficient evidence to support the findings. Comparisons among relevant groups are not appropriate or are not present.	Only vague observations or references to experiment as evidence are provided OR Only evidence that is not relevant to the claim is provided.
Reasoning: Logically connecting the claim to the evidence in an organized and well thought-out manner.	Student logically connected the claim to the evidence, clearly articulating their thought process and reasoning, and avoiding repetition.	Overall the student successfully linked their claims to the supporting evidence, but there may be minor gaps in logic and/or some repetition.	Student has partially linked their claims to the evidence, but there are major gaps in logics and/or significant repetition.	Student does not clearly link their claims to the evidence presented.