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

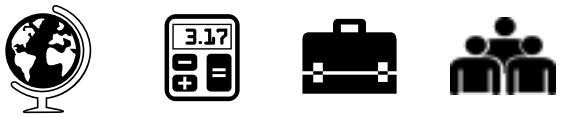
Students understand not only the economic, but also the environmental costs associated with production and consumption of food products and how external variables can affect them. Students recognize the agricultural and food production system is complex and external costs may not show up on the final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

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: see.systemsbiology.net
  - Food Security Vocabulary PowerPoint
- Student Game Rules
- Game Board
- Game Cards
- Global Fund Dollars
- Student Resource Tracker
- Student Game Analysis
- "Building Your Case" worksheet

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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.

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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

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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.

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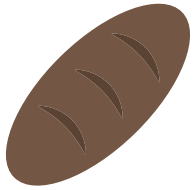
RESOURCES: RESOURCE TRACKER

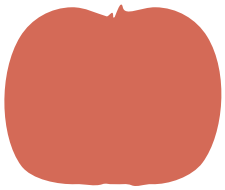
Player Name _____

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



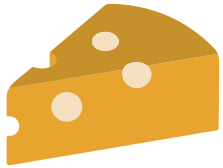
The real value of wheat:
W = 1300 liters/kg
L = 400 m^2 year x 10^3/kg
C = 0.65 kg CO^2e/kg

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



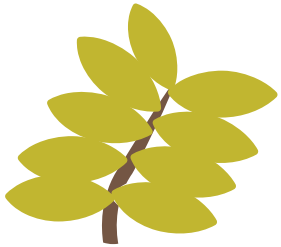
The real value of tomatoes:
W = 180 liters/kg
L = 30 m^2 year x 10^3/kg
C = 0.33 kg CO^2e/kg

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)



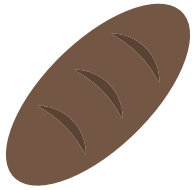
The real value of basil:
W = 180 liters/kg
L = 4 m^2 year x 10^3/kg
C = 0.33 kg CO^2e/kg

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?

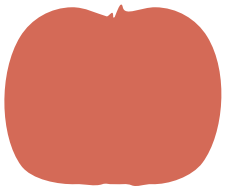
RESOURCES: GAME CARDS (CROP CARDS)

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



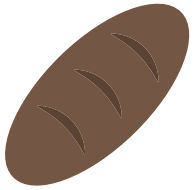
The real value of wheat:
W = 1300 liters/kg
L = 400 km2 year/kg
C = 0.65 kg CO2e/kg

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



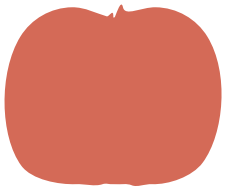
The real value of tomatoes:
W = 180 liters/kg
L = 30 km2 year/kg
C = 0.33 kg CO2e/kg

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



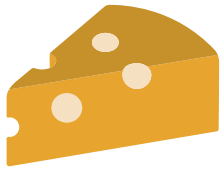
The real value of wheat:
W = 1300 liters/kg
L = 400 km2 year/kg
C = 0.65 kg CO2e/kg

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



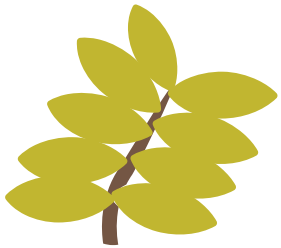
The real value of tomatoes:
W = 180 liters/kg
L = 30 km2 year/kg
C = 0.33 kg CO2e/kg

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



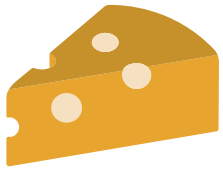
The real value of cheese:
W = 5000 liters/kg
L = 1000 km2 year/kg
C = 9.8 kg CO2e/kg

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



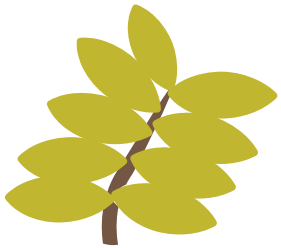
The real value of basil:
W = 180 liters/kg
L = 4 km2 year/kg
C = 0.33 kg CO2e/kg

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

$25

GLOBAL FUND DOLLARS

$25

GLOBAL FUND DOLLARS

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GLOBAL FUND DOLLARS

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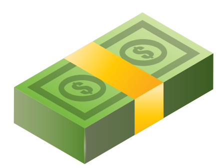
GLOBAL FUND DOLLARS

$25

GLOBAL FUND DOLLARS



$25

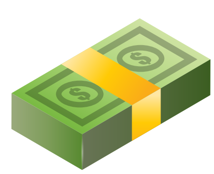
GLOBAL FUND DOLLARS

$25

GLOBAL FUND DOLLARS

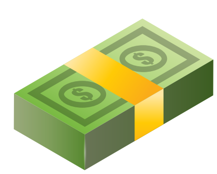
$25

GLOBAL FUND DOLLARS



$25

GLOBAL FUND DOLLARS



$25

RESOURCES: GLOBAL FUND DOLLARS

GLOBAL FUND DOLLARS

$100

GLOBAL FUND DOLLARS

$100

GLOBAL FUND DOLLARS

$100

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GLOBAL FUND DOLLARS

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GLOBAL FUND DOLLARS

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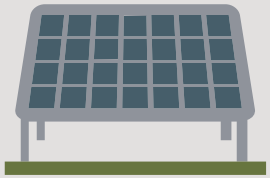
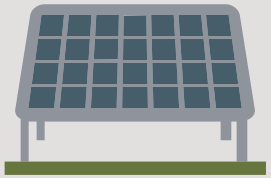
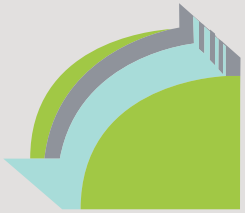
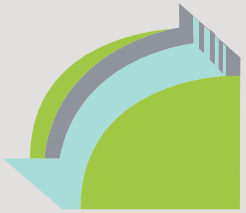
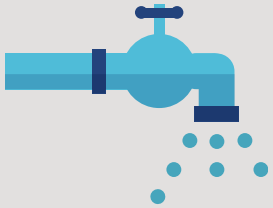
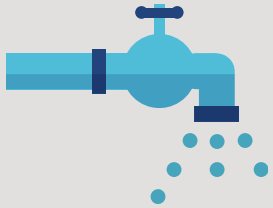
GLOBAL FUND DOLLARS

$100

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)

LESSON 6: WHERE DOES OUR FOOD COME FROM?

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