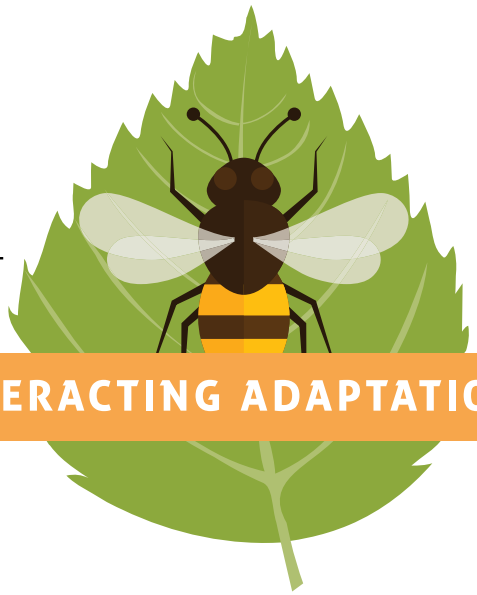
Trade-Offs in the *Agricultural Industry*



INTERACTING ADAPTATIONS

DESCRIPTION

Students conduct research on agricultural adaptations to climate change, create posters, and carry out a gallery walk to analyze the interconnectedness of adaptations.

PHENOMENON

How do adaptations to climate change interact with other components of agricultural systems?

GRADE LEVEL
6 – 12

OBJECTIVES

Students will:

- Identify the trade-offs of agricultural adaptations to various climate change effects
- Evaluate the effectiveness of agricultural adaptations to climate conditions
- Analyze the roles of actors in the agriculture industry and how they overlap

TIME
60 MINUTES

COMMON CORE STATE STANDARDS

English Language Arts Standards > Writing > Grades 6-8

CCSS.ELA-LITERACY.W.6-8.7. Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.

English Language Arts Standards > Speaking and Listening > Grades 6-8
CCSS.ELA-LITERACY.SL.6-8.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6-8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

English Language Arts Standards > Reading: Informational Text > Grade 6

CCSS.ELA-LITERACY.R1.6.7. Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in works to develop a coherent understanding of a topic of issue.

English Language Arts Standards > Writing > Grades 9-10

CCSS.ELA-LITERACY.W.9-10.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

English Language Arts Standards > Speaking and Listening > Grades 9-10

CCSS.ELA-LITERACY.SL.9-10.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9-10 topics, texts, issues, building on others' ideas and expressing their own clearly and persuasively.

English Language Arts Standards > Writing > Grades 11-12

CCSS.ELA-LITERACY.W.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

English Language Arts Standards > Speaking and Listening > Grades 11-12

CCSS.ELA-LITERACY.SL.11-12.1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 11-12 topics, texts, and issues, building on others' ideas and expressing their own clearly and persuasively.

English Language Arts Standards » Science & Technical Subjects » Grade 11-12

CCSS.ELA-LITERACY.RAT.11-12.7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

NEXT GENERATION SCIENCE STANDARDS

High School Performance Expectation

HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

NEXT GENERATION SCIENCE STANDARDS

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Engaging in Argument from Evidence (MS, HS) Obtaining, Evaluating, and Communicating Information (MS, HS)	ESS3.A Natural Resources (HS) ESS3.C Human Impacts on Earth Systems (MS, HS)	

AGRICULTURE, FOOD, AND NATURAL RESOURCES STANDARDS

CS.04.02. Assess and explain the natural resource related trends, technologies, and policies that impact AFNR systems.
CS.04.02.01.b. Analyze natural resources trends and technologies and explain how they impact AFNR systems (e.g. climate change, green technologies, water resources, etc.).
CS.06.02. Analyze and explain the connection and relationships between different AFNR systems on a national and global level (e.g. using less irrigation water, reduction of inputs, etc.).
CS.06.02.02.a. Examine and summarize changes that happen in AFNR systems on a national and global level (e.g. using less irrigation water, reduction of inputs, etc.).
ESS.03.01. Apply meteorology principles to environmental service systems.
ESS.03.01.03.b. Assess the environmental, economic, and social consequences of climate change.
ESS.03.01.03.c. Evaluate the predicted impacts of global climate change on environmental service systems.

BACKGROUND

Climate adaptations are adjustments in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderate harm or exploit beneficial opportunities. Agricultural adaptations are actions that attempt to:

- Satisfy human food and fiber needs, and contribute to biofuel needs
- Enhance environmental quality and resources, such as water or soil
- Sustain the economic viability of agriculture
- Enhance the quality of life for farmers, farm workers, and society as a whole

There are limits to agricultural adaptations to climate change; these can be ecological, social, or economic. Ecologically, many adaptations are dependent on the success of other adaptations and ecosystem services. Socially, the perception of the need for adaptation is influenced by political norms and values, as well as cultural ideologies. Economically, access to funds can limit a producer's capability to adapt. Cross-scale interactions between the three agricultural actors (producers, agro-industry, and government) and the actions they can take on some of the factors affected by climate change should be understood to avoid an increase in agricultural vulnerability to climate change. In this activity, students will examine the role of agricultural actors in adapting farming practices to reduce the negative impacts of these four effects of climate change: temperature, water availability, pests, and pollinator patterns.

MATERIALS

- *Actors and Impacts* handout [1 per student]
- *Interacting Adaptations* handout [1 per student]
- *Reference Sheet* handout [12, 1 per group]
- Set of 12 *Impact* cards
- Set of 12 *Actor* cards
- PowerPoint presentation
- Computer and projector
- Set of four colors of sticky notes (yellow, green, blue, and pink) [3 sets]
- Set of four colors of highlighters (yellow, green, blue, and pink) [12 sets]
- 12 blank poster pages from self-stick easel pad (25 x 30.5 inches or similar size) [1 set per class]
- Markers (a variety of colors for 12 groups)

PREPARATION

1. Plan to divide the class into 12 groups. This will allow for enough groups for each impact/actor combination. If fewer groups are preferable, the pest and pollinator impacts can be combined, reducing the number of groups to 9.
2. Prepare Impact cards (3 temperature, 3 water, 3 pest, 3 pollinator):
   a. Print the Impact cards document (quantity: 3 total) double sided (short edge binding).
   b. Cut the cards, 4 per each double sided sheet.

3. Prepare Actor cards (4 producer, 4 agro-industry, 4 government):
   a. Print the Actor cards document (quantity: 4 total) double sided (short edge binding).
   b. Cut the cards, 3 per each double sided sheet

PROCEDURES

1. Give an introduction to agricultural adaptations to climate change using the PowerPoint presentation.
   a. **Slide 2**: we are going to use California as a case study to learn about how agricultural actors can react to climate change. California is an ecologically diverse state. Within its borders are desert, Mediterranean, forested mountains, and coastal mountain systems.
   b. **Slide 3**: California is also home to many large- and small-scale agricultural producers. Nearly half of the fruit, vegetables, and nuts in the US are produced in California. Several crops are only producible in California because of the diverse ecosystems there.
   c. **Slide 4**: the state has been in a severe drought since 2012. California's 2014 and 2015 water years (12 month precipitation totals) were the warmest on record causing Governor Jerry Brown to declare a state of emergency for the state in 2014. What would you do in this situation?
   d. **Slide 5**: in response to the drought, some farmers started digging more wells to tap into groundwater supplies to compensate for the decreased amount of surface water. **Groundwater** is supplied by underground aquifers that are gradually replenished by rain, rivers, streams, and irrigation as it percolates through the soil. This became a popular way for farmers to adapt to sustain their crops through a changing climate. Accessing groundwater became such a popular short-term solution to the drought that many counties saw a dramatic increase in drilling permits over a five-year period.
   e. **Slide 6**: in response to this severe drought, many farmers adjusted their methods to sustain their crops as climate factors changed. When farmers and ranchers alter their practices to meet the needs of a changing climate it is called an **adaptation**. An adaptation is an adjustment in human systems as a response to actual or expected climatic effects, which moderates harm or exploits beneficial opportunities.
   f. **Slide 7**: some of these agricultural adaptations will have short-term benefits that allow crops to grow well but will also have long-term effects that can have a greater, potentially negative, effect on future productivity. Accessing groundwater has been a method used by farmers for decades. In this picture, the telephone pole has three numbers on it. The number at the top is 1925; this is where the ground level was in that year. The middle number is 1955, and the number at the bottom is 1977. Tapping into groundwater for irrigation purposes caused this dramatic change in the ground level, called subsidence, because the aquifers underneath this area have been diminished. In addition, it is very expensive to dig the wells that access the groundwater. These are examples of trade-offs. In the short-term, crops are getting watered, but in the long run, it costs a lot of money. Also, the aquifers are not getting replenished as quickly as they are getting used.
   g. **Slide 8**: there are no quick fixes for farmers to adapt to climate change because the effects can be related. For example, when farmers experience decreased water availability, they are often dealing with increased temperature as well. Adapting to climate change is also going to require knowledge about how the climate will change in the future and of the impacts of various adaptation methods. Many of these methods can be expensive, so adapting to climate change can be financially challenging. These are some of the trade-offs that farmers have to consider.
   h. **Slide 9**: farmers are not the only ones who need to adapt to climate change; the agricultural industry and government should adjust their practices and policies to support agricultural sustainability because the effects of climate change will affect all three actors.

PART 1

1. Introduce the activity setup using the PowerPoint presentation.
   a. **Slide 10**: for our activity today, we will be exploring the roles of three different agriculture actors (producers, agro-industry, and government) and how they can react to four different pressures placed on agriculture as a result of climate change.
      i. Producers are farm operators.
      ii. Agro-industry is made up of the businesses associated with agriculture. This can be through researching technologies or disseminating information/ products to producers.
      iii. Government consists of the agencies responsible for programs and policies supporting the producers and agro-industry.
   b. **Slide 11**: you will be separated into 12 groups (no more than 3 students per group) and each group will receive an *Actor* card that describes one of the three agriculture actors.
   c. **Slide 12**: each group will also draw an *Impact* card. As a result

of climate change, temperature will change, water availability will change, pests will change, and pollinators will change. When you get your *Impact* card, read aloud the impact climate change will have on your group.

PART 2

1. Pass out an *Actors* and *Impacts* handout to each student and a *Reference Sheet* handout and set of highlighters to each group.
2. Introduce the research portion of the activity using the PowerPoint presentation.
   a. **Slide 13**: in today's activity, we will ultimately make posters about our assigned actors and the impacts of climate change and then conduct a gallery walk. First, we will learn more about the actors involved and climate impacts by doing some research. Take a few minutes to read the descriptions of all of the actors and impacts on the *Reference Sheet* handout.
      i. On the *Actors* and *Impacts* handout is a list of adaptations. You will read through each adaptation and identify which actor is responsible for each. Then color code each adaptation using highlighters: yellow for temperature, green for pests, blue for water, and pink for pollinators. Use the *Reference Sheet* handout as needed.
      ii. The first one is done for you as an example. Adaptation # 1 should be highlighted green because it has to do with pests. "Agro-industry" is the actor that should be written in the blank because they are involved in researching technology.
3. Optional: if time permits and technology resources are available, allow students to conduct their own online research on their actors and impacts instead of using the *Actors and Impacts* handout. See the Extensions section below for instructions.
4. Use the *Actors and Impacts* handout answer key to lead a discussion with students, making sure that they have all of the correct answers on their Actors and Impacts handout and understand them. Students will use this handout to create their posters in Part 3.

PART 3

1. Give each group a poster page from a self-stick easel pad and a selection of markers.
2. Explain student poster creation using the PowerPoint presentation.
   a. **Slide 14**: your group will now create a poster for our gallery walk.
      i. Begin by writing your actor and impact in large print at the top of your poster.
      ii. Look on your *Actors and Impacts* handout to find the 2-3 adaptations that apply to your actor/impact combination and list them on your poster.
      iii. Once you have finished listing your adaptations, find a spot along the wall to hang your poster.
   b. **Slide 15**: each group will now receive a pad of sticky notes based on their impact: yellow for temperature, green for pests, blue for water, and pink for pollinators. You will walk around the room as a group and review each poster and consider how the adaptations may apply to your impact.
   c. **Slide 16**: if an adaptation would apply to your impact, mark it with a sticky note. If it would have a positive effect, add a plus sign to the sticky note. If it would have a negative effect, add a minus sign to the sticky note.
      i. For example, if producers add shade structures to reduce the impact of increased temperature, it will also decrease evaporation from soil and evapotranspiration from plants, increasing water efficiency. This adaptation would affect both temperature and water. The groups that researched water would add a blue sticky note next to that adaptation. It would have a positive impact, so those groups would add a plus sign to their sticky note.
      ii. Optional: instruct students to write how the adaptation could affect their actor/impact in addition to the plus or minus sign.

PART 4

1. Once students have had the chance to visit each poster and add sticky notes with their groups, ask them to return their seats.
2. Pass out an *Interacting Adaptations* handout to each student.
3. Use the PowerPoint presentation to lead a discussion about the gallery walk.
   a. **Slide 17**: look around the room at all of the posters. What is something that you notice? [Answer: most posters have multiple sticky notes or posters have different colored sticky notes on them.]
4. Ask students to answer question 1 on the *Interacting Adaptations* handout. Give them a few moments to write down their answers, and then engage students in a discussion about their answers. Touch on the idea of trade-offs during the discussion:
   a. As we have demonstrated, all of the agriculture actors and all of the climate change impacts are connected. Each adaptation has trade-offs. Producers, the agriculture industry, and the government must consider these trade-offs when adapting to climate change. There is no perfect solution, but with knowledge of how these factors affect one another and some cooperation, all agriculture

actors can make the most informed, sustainable decision. [Seek out some sticky-notes with a minus sign to talk about trade-offs with these adaptations.]

5. Return to the PowerPoint presentation to wrap up the activity.
   a. **Slide 18**: remember the California example at the beginning of the today's activity. Farmers in several areas, such as Tulare County, are digging more wells to tap into the groundwater supply.
6. Ask students to answer question 2 on the *Interacting Adaptations* handout. Give them a few moments to write down their answers, and then engage students in a discussion about their answers.

EXTENSIONS

1. Use computers with internet access for students to conduct research online instead of using the *Actors and Impacts* handout. The goal is for students to research ways that their actor can adapt to the assigned climate impact. Students should find at least three adaptations that their actor can implement to mitigate the effects of their climate impact. If students are experienced with finding reliable internet sources, they can be allowed to conduct the research independently, but if they may need more help, the educator can provide these websites as helpful resources:
   a. https://swclimatehub.info/adaptation-menu-crops
   b. https://www.usda.gov/oce/climate_change/effects_2012/effects_agriculture.htm
   c. https://www.cdfa.ca.gov/environmentalstewardship/pdfs/ccc-report.pdf
2. Before the activity, have students read a New York Times article from June 5, 2015, "California Farmers Dig Deeper for Water, Sipping their Neighbors Dry." It is a real-world example of an agricultural adaptation with trade-offs and possibly serious consequences. The article can be accessed online: http://www.nytimes.com/2015/06/07/business/energy-environment/california-farmers-dig-deeper-for-water-sipping-their-neighbors-dry.html

ADDITIONAL RESOURCES

Reports, articles, and websites with helpful background information on agricultural adaptations:

California Department of Food and Agriculture (CDFA). Climate Change Consortium for Specialty Crops: Impacts and Strategies for Resilience. Published 2013. Accessed online 22 Jan. 2016. <https://www.cdfa.ca.gov/environmentalstewardship/pdfs/ccc-report.pdf>.

Howden. S, Soussana, J, Tubiello, F, Chhetri, N, Dunlop, M, and Meinke, H. 2007. Adapting agriculture to climate change. The Proceedings of National Academy of Sciences 104(50), 19691-19696. Accessed online 29 Mar. 2016. <http://www.pnas.org/cgi/doi/10.1073/pnas.0701890104>.

Intergovernmental Panel on Climate Change (IPCC). 2014. Climate Change 2014: Synthesis Report. Accessed online 29 Mar. 2016. <http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf>.

United States Department of Agriculture (USDA). Agricultural Research Service. Climate Change and Agriculture in the United States: Effects and Adaptations. Published Feb. 2013. Web. Accessed 22 Jan. 2016. <http://www.usda.gov/oce/climate_change/effects.htm>.