



DESCRIPTION

Students play a Chutes-and-Ladders-style board game to understand the effects of climate change on the water cycle.

PHENOMENON

How is climate change impacting the cycling of water through Earth's reservoirs?

GRADE LEVEL 6 – 12

OBJECTIVES

Students will:

- Predict how increasing temperatures on Earth will affect the water cycle
- Synthesize information about the effects of climate change on the water cycle
- Explain how changes in the water cycle affect humans

TIME
50 MINUTES –
1 HOUR

COMMON CORE STATE STANDARDS

English Language Arts Standards » Science & Technical Subjects » Grade 6-8

CCSS.ELA-LITERACY.RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts. [Extension Activity]

CCSS.ELA-LITERACY.RST.6-8.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6-8 texts and topics.

CCSS.ELA-LITERACY.RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

English Language Arts Standards » Science & Technical Subjects » Grade 9-10

CCSS.ELA-LITERACY.RST.9-10.1. Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions. [Extension Activity]

CCSS.ELA-LITERACY.RST.9-10.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9-10 texts and topics.

CCSS.ELA-LITERACY.RST.9-10.7. Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.

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

CCSS.ELA-LITERACY.RST.11-12.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. [Extension Activity]

CCSS.ELA-LITERACY.RST.11-12.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11-12 texts and topics.

NEXT GENERATION SCIENCE STANDARDS

High School Performance Expectation

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions (MS, HS)	ESS2.A Earth Materials and Systems (MS, HS) ESS3.A Natural Resources (MS, HS) ESS3.C Human Impacts on Earth Systems (MS, HS)	Cause and Effect (MS, HS)

BACKGROUND

The availability of water resources for humans, our crops, and our livestock is changing because of the enhanced greenhouse effect and resulting global warming and climate change.

The greenhouse effect ensures that Earth is warm enough to sustain life. Electromagnetic radiation from the sun, mostly at short wavelengths in the form of light, is able to pass through the atmosphere and is absorbed by Earth. Earth re-radiates some of this energy back toward space as heat, more of which was able to pass through the atmosphere and escape into space historically. We are currently experiencing the enhanced greenhouse effect, however, which is caused by increased greenhouse gases in our atmosphere. As higher levels of greenhouse gases are released into the atmosphere, more of the re-radiated heat from Earth is re-emitted back to Earth instead of escaping to space. This is causing the average global temperature to increase. The increasing temperature of Earth is called **global warming**.

Global warming is leading to additional changes to our climate, such as increased frequency of extreme weather events and changing precipitation patterns, wind patterns, and length of seasons. These long-term changes in measures of climate are called **climate change**.

The **water cycle** is the movement of water on, in, and above Earth, and it is largely driven by energy from short-wave electromagnetic radiation (sunlight) absorbed by Earth's surface. The effects of climate change on the water cycle are numerous because of how warmer temperatures affect water cycle processes. Warmer water evaporates more readily, and warmer air has the capacity to hold more water vapor. As a result, in some areas, the frequency of intense precipitation events will increase, and other areas will experience more drought. Also, because of higher temperatures, more precipitation is falling as rain instead of snow. In parts of the Northern Hemisphere, early arrival of warm spring season temperatures results in earlier snowmelt and altered streamflows.

MATERIALS

- [What Is Happening to Our Water? handout](#) [1 per student]
- [Streams and Steam handout](#) [1 per student]
- [Streams and Steam](#) game board, in [black and white](#) or [color](#) [1 per every 4 students]
- Optional: [Water Cycle](#) diagram, in [black and white](#) or [color](#) [1 per every 1-4 students]
- [PowerPoint presentation](#)
- Computer and projector
- Four unique coins, e.g. penny, nickel, dime, and quarter [1 set per every four students]
- Die [1 per every four students]

PREPARATION

1. Plan to divide students into groups of four. If necessary, smaller groups are also acceptable.
2. Make the *Streams and Steam* game boards. Trim the bottom edge of the top half of the *Streams and Steam* game board, cutting away the white and blue/grey edges. Trim the top edge of the bottom half of the *Streams and Steam* game board, cutting away the white and blue/grey edges. Place the two halves together, align the game squares at the border, and tape the halves together.
3. Set up a computer and projector and display the PowerPoint presentation.

PROCEDURES

1. Pass out a *What is Happening to Our Water?* handout to each student.
2. Instruct students to read the excerpt at the top of the handout.
3. Once most students have had enough time to read the excerpt, introduce the activity with the PowerPoint presentation.
 - a. **Slide 2:** Earth is getting warmer because of the enhanced greenhouse effect. Increased greenhouse gases in the atmosphere have resulted in global warming, which includes higher global surface temperatures and also higher air and water temperatures. (Review the greenhouse effect and global warming if needed.)
 - b. Optional: pass out copies of the *Water Cycle* diagram.
 - c. Ask students to draw on their understanding of the water cycle to predict the effects of warmer air and water temperatures on the processes of the water cycle; direct them to write their predictions on the handout. Students can use the *Water Cycle* diagram (if they have a copy) and the excerpt at the top of the handout.
4. Divide students into groups of four.
5. Pass out a *Streams and Steam* handout to each student.
6. Pass out a completed *Streams and Steam* game board to each group.
7. Use the PowerPoint presentation to explain the game.

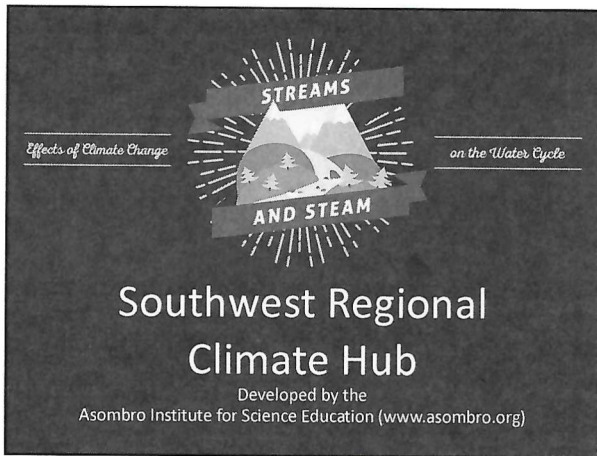
- a. **Slide 3:** this is the Streams and Steam game board. The game is played like Chutes and Ladders.
 - b. **Slide 4:** rules of the game:
 - i. Roll the die to determine who starts the game.
 - ii. The player who rolls the highest number goes first.
 - iii. Players follow in turn from left to right.
 - iv. All players begin with their coin on the start space.
 - v. Roll the die and move the coin the number of spaces indicated.
 - vi. When a player lands on a space that is at the top of a stream, they will "raft" down the stream by moving their coin to the square at the bottom of the stream.
 1. Move in the direction of the arrows, from the smaller to larger end of the stream.
 - vii. When a player lands on a space that is at the bottom of a column of steam, they will rise up the column of steam by moving their coin up to the square at the top of the steam column.
 1. Move in the direction of the arrows, from smaller to larger puffs of steam.
 - viii. The squares without pictures do not require any further action. The player will rest there until their next turn.
 - ix. Two or more players may stop at the same square together.
 - x. The first player to cross into the finish space wins the game. An exact roll of the die is not required to win.
8. In the table in question #1 on the handout, instruct students to list all of the causes and effects that each student from their group lands on during the game. On the game board, causes are written in the beginning stream or steam square, and effects are listed in the square where the stream or steam ends. Example, cause: increased evaporation; effect: more water in the atmosphere.
- a. Instruct students to only write each pair of causes and effects **once** if they are landed on multiple times.
9. Pass out a set of four unique coins and a die to each group. Ask students to give each player one coin and begin playing.
 10. Play as many rounds of the game as time permits. One round of the game takes approximately 10 - 15 minutes.
 11. Ask students to volunteer to summarize the effects of climate change on the water cycle that they learned from playing *Streams and Steam*. Return to the PowerPoint presentation to review the effects summarized by students and to wrap up the activity.
 - a. **Slide 5:** Review some of the important effects of climate change on the water cycle.
 - i. Because surface, air, and water temperatures on Earth are increasing, there is a higher rate of evaporation of water into the atmosphere. Warmer air holds more water, which changes precipitation patterns. Also, water vapor is a greenhouse gas, so more water in the atmosphere further enhances the greenhouse effect and changes the climate.
 - ii. We will experience more severe drought in some areas. As climate change intensifies, climate scientists predict less rainfall in the Mediterranean, southwest North America, and southern Africa.
 - iii. Earth will receive increased precipitation in some areas. More precipitation is predicted in Alaska and other high latitudes of the Northern Hemisphere and near the equator.
 - iv. As global surface temperatures continue to increase, most areas on Earth will have warmer winter temperatures.
1. Warmer winter temperatures mean that more precipitation falls as rain instead of snow. Snowpack will be reduced, and there will be less water stored in snow to supply watersheds.
 2. With warmer winters and spring-like temperatures coming earlier, snow is melting earlier, altering the timing of streamflow. The increased temperature in springtime increases evaporation from surface water bodies, reducing overall streamflow. This generally means that less water is available during late spring and summer months when demand is highest for crops, livestock, and general public use.
12. Ask students to explain how these changes to the water cycle will affect humans [possible answers: less water available for crops, livestock, and general public use; less food available because of decreased water supply for crops and livestock and increased water temperatures in fisheries; loss of life and property due to flooding and more extreme weather events; increased soil erosion due to flooding and drought; less snow for recreation; changes in ability to produce hydroelectric power because of changes in streamflow].

EXTENSIONS

1. Students read the National Public Radio (NPR) article, "[There's a Big Leak in America's Water Tower,](#)" and answer the associated questions.
2. Have students take action to conserve water by developing and implementing a water education campaign for their community, a water conservation plan for their home or school, or a similar action project of their choice.

ADDITIONAL RESOURCES

1. Websites with background information about the effects of climate change on the water cycle:
Environmental Protection Agency (EPA), Water Resources. Climate Impacts on Water Resources. Updated 25 Mar. 2015. Web. Accessed 11 May 2015. <<http://www3.epa.gov/climatechange/impacts/water.html>>.
National Aeronautics and Space Administration (NASA), Earth Observatory. The Water Cycle and Climate Change. Web. Accessed 7 May 2015. <<http://earthobservatory.nasa.gov/Features/Water/page3.php>>.
2. Online quiz about the effects of global warming on the water cycle for students:
National Oceanic and Atmospheric Administration (NOAA), Ocean Explorer. Global Warming and the Water Cycle. Modified 12 Feb. 2013. Web. Accessed 30 Apr. 2015. <http://oceanexplorer.noaa.gov/edu/learning/7_water_cycle/activities/global_warming.html>.

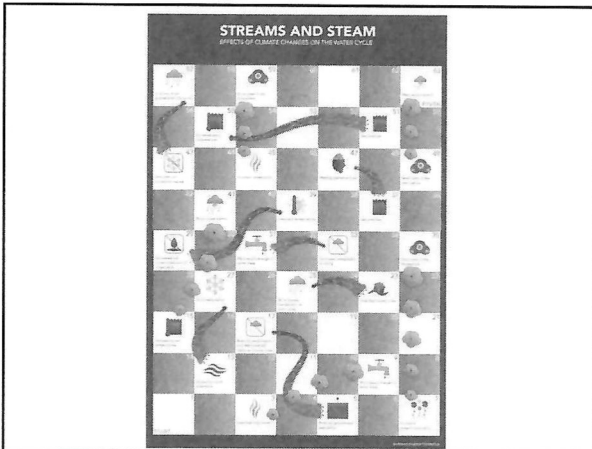


1

Effects of Climate Change

- **Global warming: warmer air and water**
- **What effects would you expect?**
 - **Think about water cycle, evaporation experiment**

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3

Rules of Play

1. Roll the die to determine who starts the game.
2. Player who rolls the highest number plays first.
3. Players follow in turn from left to right.
4. All players begin with their coin on the start space.
5. Roll die and move the coin the number of spaces indicated.
6. When a player lands on a square at the **TOP** of a stream, the player will "raft" down the stream by moving their coin down to the square at the bottom of the stream.
7. When a player lands on a square at the **BOTTOM** of a column of steam, the player will rise up the steam column by moving their coin up to the square at the top of the steam column.
8. The squares without pictures are regular squares and do not require any further action.
9. Two or more players may stop at the same square together.
10. The first player to cross into the finish space wins the game; an exact roll of the die is not required to win.

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Effects of Climate Change

- **Increased rate of evaporation into atmosphere**
- **More severe drought in some areas**
- **Increased precipitation in some areas**
- **Warmer winter temperatures**
 - **More precipitation as rain instead of snow**
 - **Snowmelt earlier, timing of streamflow**

Source: www.epa.gov/climatechange/impacts-adaptation/water.html#watercycles

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Name _____ Date _____



Effects of Climate Change

on the Water Cycle

DIRECTIONS

Please follow the rules below to play a round of Streams and Steam with your group, and answer the questions.

RULES OF PLAY

1. Roll the die to determine who starts the game.
2. Player who rolls the highest number plays first.
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7. When a player lands on a square at the BOTTOM of a column of steam, the player will rise up the steam column by moving their coin up to the square at the top of the steam column.
8. The squares without pictures are regular squares and do not require any further action.
9. Two or more players may stop at the same square together.
10. The first player to cross into the finish space wins the game; an exact roll of the die is not required to win.

QUESTIONS

1. List all of the causes and effects that you and your group members land on when you go down a stream and/or up a column of steam while playing Streams and Steam. Only write each pair of causes and effects **once** if it is landed on multiple times.

CAUSE

EFFECT

2. Choose one of the effects from question #1. Explain how this change to the water cycle affects humans.

ANSWER KEY



Effects of Climate Change

on the Water Cycle

DIRECTIONS

Please follow the rules below to play a round of Streams and Steam with your group, and answer the questions.

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1. Roll the die to determine who starts the game.
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7. When a player lands on a square at the BOTTOM of a column of steam, the player will rise up the steam column by moving their coin up to the square at the top of the steam column.
8. The squares without pictures are regular squares and do not require any further action.
9. Two or more players may stop at the same square together.
10. The first player to cross into the finish space wins the game; an exact roll of the die is not required to win.

QUESTIONS

1. List all of the causes and effects that you can think of when you go down a stream and/or up a column of steam **once** if it is landed on multiple squares. List each pair of causes and effects.

Student answers will vary but may include any or all of these answers

CAUSE

*Increased evaporation
Increased evapotranspiration
Increased ocean temperatures
Reduced precipitation and decreased soil moisture in some areas
More intense precipitation in some areas
Decreased precipitation in spring
Increased temperatures
Increased evaporation
Melting glaciers and ice
More water in the atmosphere
Increased ocean temperatures
In winter, more precipitation falls as rain*

EFFECT

*More severe drought in some areas
More water in the atmosphere
More severe storms
Reduced groundwater availability
Flooding in some areas
More severe drought in some areas
Decreased soil moisture because of evaporation
More water in the atmosphere
Sea level rise
More severe storms
Sea level rise
Less snow and reduced snowpack*

2. Choose one of the effects from question #1. Explain how this change to the water cycle affects humans.

- *More severe drought in some areas: less water available for crops, livestock, and general public use*
- *More water in the atmosphere: will lead to increased precipitation and flooding in some areas, which could result in property damage and human health effects; also, water vapor is a greenhouse gas, so more water in the atmosphere further enhances the greenhouse effect and changes the climate*
- *More severe storms: property damage, human health effects, loss of life*
- *Reduced groundwater availability: less water available for crops, livestock, and general public use*
- *Flooding in some areas: property damage, human health effects, loss of life*
- *Decreased soil moisture because of evaporation: less water available for crops, increased soil erosion, which could result in fewer nutrients available for crops*
- *Sea level rise: erosion of beach sand and reduction of recreation opportunities and impact to the tourism economy, property damage, displacement of waterfront and island property owners, loss of life*
- *Less snow and reduced snowpack: less water stored in snow to supply watersheds (so less water available for crops, livestock, and general public use), reduction of recreational opportunities and impact to the tourism economy*