Environmental Studies Department
ENST-107 Global Change and Sustainability
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Exploring the interconnectedness of climate change and the water cycle to justify prioritizing sustainable water infrastructure within policies and actions to mitigate climate change

Overview

In this lesson and accompanying activity, students will make connections between climate change and the water cycle, realizing that water is an essential element of the Earth's climate. After considering this relationship they will analyze the significant effects climate change is having on the water cycle and the problems it is causing now as well as in the future. Then, students will be presented with a variety of solutions to this issue that focus on encouraging sustainable practices. The lesson incorporates content from the National Oceanic and Atmospheric Administration (NOAA), International Union for Conservation of Nature (IUCN), and the Ecologos Environmental Organization. This lesson can be used to further inform students about why it is crucial to consider water when creating climate change reforms and give them the tools and knowledge to argue in favor of sustainable reforms regarding water (*See Culminating Activity*).

Topics Covered

Climate Change
Climate Variability
Extreme Weather Events (Flooding, droughts, intense rainfall, etc.)
Freshwater resources
Groundwater vs Surface water
Mitigation measures
Natural vs Engineered infrastructure
Resilience
Sea level rise
Water Cycle
Water scarcity/stress

Learning Objectives

Upon completion of this lesson, students will be able to:

- Describe the different types of freshwater sources

- Describe the water cycle and its relationship to climate change
- List the effects climate change has on the water cycle
- Describe how humanity and the Earth's ecosystem are negatively impacted by this relationship
- List solutions that help to develop climate resilience and mitigate climate change

Curriculum Alignment

Climate change and the water cycle affect humans, land, and animals therefore making this a multidisciplinary lesson that can be taught to any students between 9th and 12th grade.
This lesson can be taught in any of the following units within the Advanced Placement (AP) classes listed below.

AP Environmental Science	*AP Human Geography*	*AP Biology*
• Unit 5: Land and Water Use • Unit 7: Atmospheric Pollution • Unit 9: Global Change	• Unit 2: Population and Migration Patterns and Processes • Unit 5: Agriculture and Rural Land Use Patterns and Processes	• Unit 8: Ecology

Instructional Materials

- Internet Access
- Companion Google Slides
- Half sheets of lined paper, one per student (*World Water Day Activity*)
- Organizer for students to take notes on the material discussed in the lecture
    - Provided below in Google Doc Format
- Worksheet for students to participate in the culminating activity
    - Provided below in Google Doc Format
- (Optional) Before class provide access to the *New York Times Article "*These Maps Tell the Story of Two Americas: One Parched, One Soaked.*"*
    - This article provides context for students in the United States as the issue that is going to be discussed in the lesson is impacting the entire world
    - The *New York Times* article is linked here

Background Information for Teacher

According to the article *5 reasons why the climate crisis is a water crisis* by Marie Skold that was published by the Stockholm International Water Institute, "The most profound effect of global warming is how it affects the water cycle. Until now, this simple fact has often been overlooked, but it is starting to be painfully obvious across the world. The number of extreme

weather events is rising, for example, floods and droughts. Rainfalls and seasons are also becoming more unpredictable." Now, according to many scientists the increase of these extreme weather events will lead to increased water scarcity around the world over the next couple decades. Many models are predicting that the effects climate change is having on the water cycle will not be limited to developing countries with high levels of poverty or countries that have particularly hot climates. As climate change starts to affect people regardless of socioeconomic status, education about the problems that will occur and possible solutions to them is becoming more vital every day. It is important to educate people about how we can use the Earth's natural resources to make our current freshwater infrastructure more resilient and sustainable for the future.

Lesson Overview

Activity	**Instructional Time Needed**
Explore the role water plays in our lives	10-15 minutes
Explain the sources of drinking water	5-7 minutes
Review the water cycle	5-7 minutes
Identify the relationship between water and climate change	7-9 minutes
Identify the relationship's effects	7-9 minutes
Discuss impacts on the Earth's ecosystem	8-10 minutes
Discuss impacts on humanity	8-10 minutes
Identify possible solutions	10 minutes
Total lesson time:	60-77 Minutes

Student Preparation

Students should have knowledge of these topics **prior to participating in the lesson**:

- A general understanding of what has caused climate change to become such a prevalent issue and the effects it is having on the planet
- Familiarity with the water cycle from taking science classes prior to high school
- A general sense of the water scarcity issues that were occurring before the severe impacts of climate change

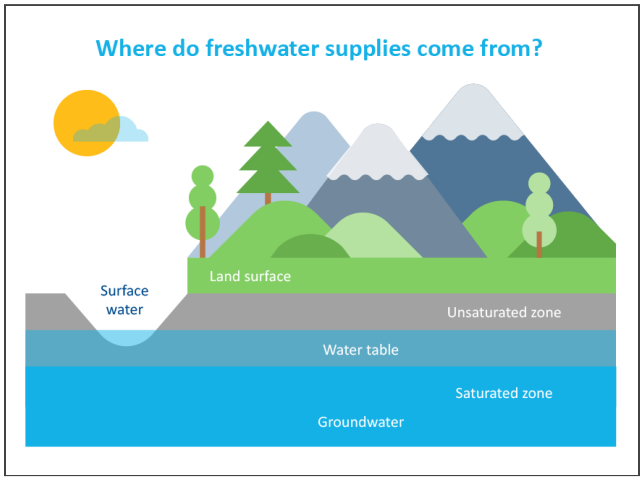
Procedure of Lesson

1. **Explore the role water plays in our lives:** Introduce students to the World Water Day challenge (slide 2) and hand out half sheets of paper. Students should take 5-7 minutes on their own to brainstorm answers to the questions on slide 2. Answer any questions students may have. (See https://www.worldwaterday.org/ for up-to-date information about the challenge)

2. Switch to project slide 3. Ask the class to share some of their responses from the activity to develop a consensus of the class's current understanding regarding groundwater. To further the conversation, ask if students can name any other sources of fresh water besides groundwater. *Before moving on, inform students that the first section on their graphic organizer is coming up next.*

3. **Explain the sources of drinking water:** Click forward to reveal graphics providing more detail about where in nature our drinking water comes from. Introduce the difference between groundwater and surface water

Figure 1. Diagram of various freshwater resources. *Source: Waterlogic.* https://www.waterlogic.com/en-us/resources-blog/where-does-our-drinking-water- actually-come-from/.



4. **Review the Water Cycle:** Slide 4 is a review of the water cycle. Ask students if they have any clarifying questions and review the following **terminology**:
   - Phases of the water cycle
     - Solid, liquid, gas
   - Major climate systems
     - Clouds, air, ocean, lakes, snow, vegetation
   - Interconnectedness

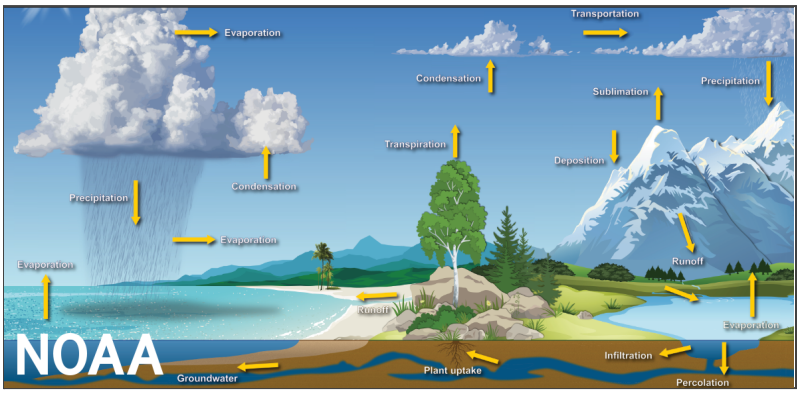


Figure 2. Diagram of the water cycle. *Source: Water Cycle NOAA.* https://www.noaa.gov/education/resource-collections/freshwater/water-cycle

5. **Identify the relationship between water and climate change:** On slide 5 students will have an opportunity to listen to Mark Smith who is the director of the International Water Management Institute. Before playing the video ask students if they think water and climate change are related.

6. Note that many of the ideas Mark briefly discussed in the video will be further explained later in the class. This should spark interest or concern about the relationship between water and climate change. (See https://www.iucn.org/resources/issues-briefs /water-and- climate- change for video)

7. **Identify the relationship's effects:** Slide 6 will explain the different ways that climate change is causing changes, specifically among the water cycle and ecosystems. Be sure to point out the different extreme weather events that will increase in severity due to temperatures increasing.

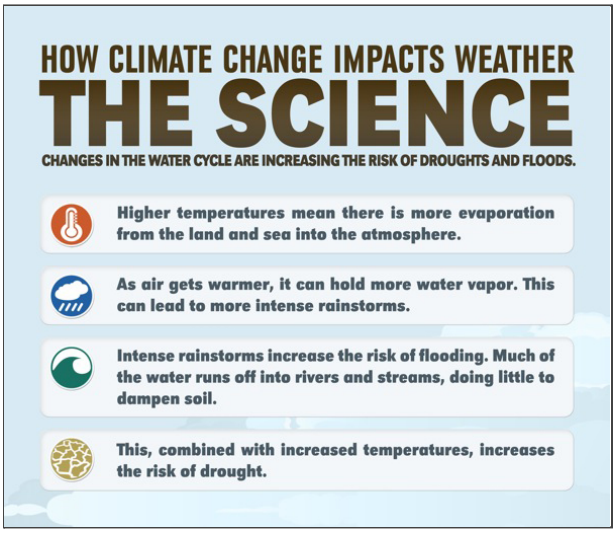


Figure 3. How climate change impacts the water cycle and weather. *Source: Water Docs.* https://www.waterdocs.ca/water-talk/2018/9/19/5-ways-climate-change-impacts-water.

8. **Discuss impacts on Earth's ecosystem:** Slide 7 details the negative effect that climate change will have on our natural water resources, land, and weather.

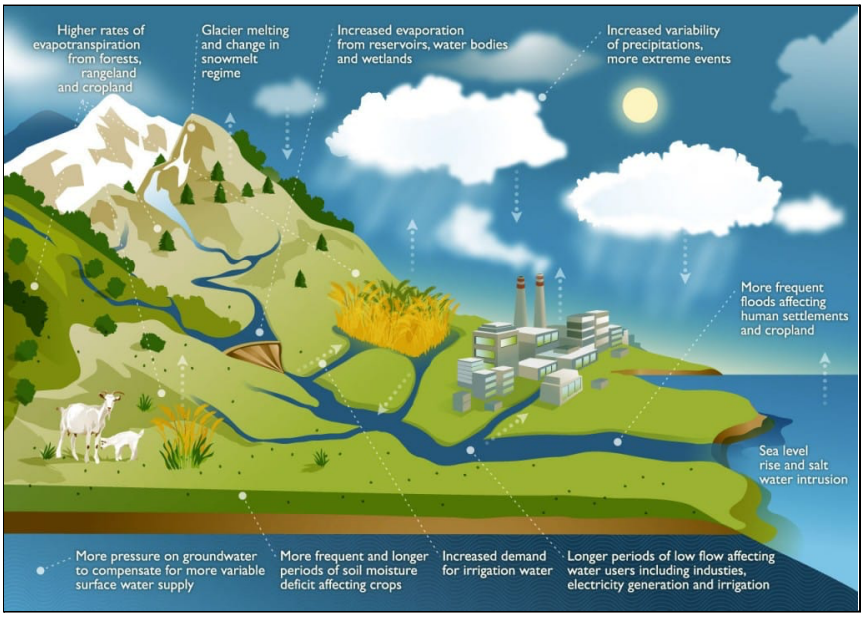


Figure 4. How climate change causes water and food scarcity. *Source: Abundance NC.* https://abundancenc.org/climate-change-gmo-crops-threaten-food-security/.

9. **Discuss impacts on humanity:** Slide 8 will display this graphic to the class depicting the inevitable future water stress given the fact that effects of climate change are worsening. Be sure to emphasize the connection between droughts, floods and rising sea levels and increasing water stress.

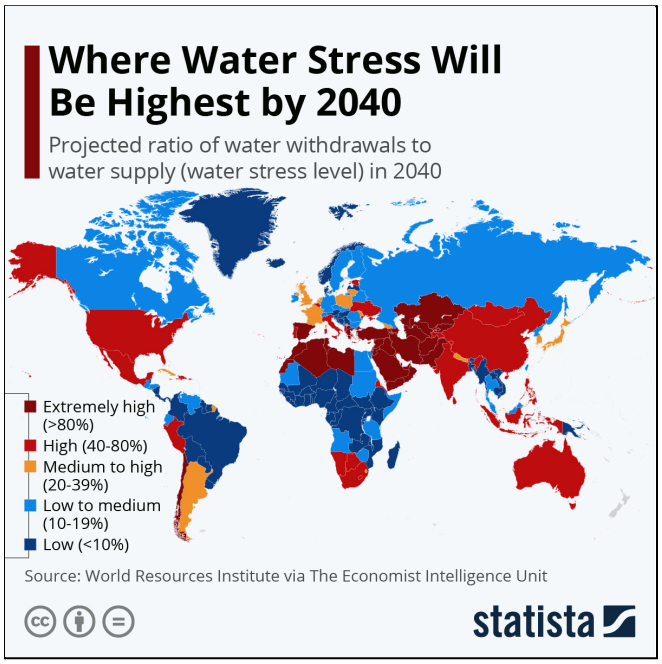


Figure 5. Predicted water stress level by 2040. *Source: Infographic.* https://www.statista.com/chart/26140/water-stress-projections-global/.

10. **Identify Possible Solutions:** On slide 9 focus on the comparison between engineered infrastructure and the benefits that can be realized when you combine it with natural infrastructure.

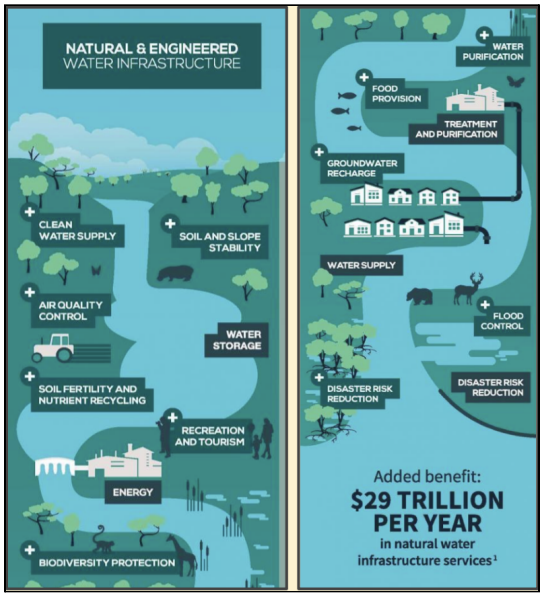


Figure 5. Combining natural and engineered water infrastructure. *Source: IUCN.* https://www.iucn.org/resources/issues-briefs/water-and-climate-change.

11. Slide 10 will introduce a list of solutions to help promote climate resilience. Relate some of these solutions back to the Mark Smith videos and the broader solutions he discussed.

Figure 5. Ways to increase climate resilience. *Source: IUCN.* https://www.iucn.org/resources/issues-briefs/water-and-climate-change.

12. This is the end of the presentation. Move on to slide 11 and welcome any questions or comments about the presentation.

13. If there are no questions, explain the culminating activity and pass out the respective worksheet.

14. Be sure to mention that the graphic organizer and the culminating activity will be collected at the beginning of next class.

Culminating Activity

Evaluate what students have taken away from this lesson by having them write a response to two of the four questions included on the culminating activity handout. This should encourage students to not only display the information they have learned but apply it to questions that may not have been directly answered in the lesson. In total students should write 6-8 sentences responding to these questions and turn in their response at the beginning of next class. *(Refer to Culminating Activity handout below)*

Resources

Ahmad, Sidrah. "Where Does Our Drinking Water Actually Come from?" *Waterlogic*, 1 July 2019, https://www.waterlogic.com/en-us/resources-blog/where-does-our-drinking-water-actually-come-from/.

Armstrong, Martin. "Infographic: Where Water Stress Will Be Highest by 2040." *Statista Infographics*, 22 Mar. 2022, https://www.statista.com/chart/26140/water-stress-projections-global/.

"Climate Change, Environmental Degradation, Water Scarcity Threaten Food Security." *Abundance NC*, 13 Oct. 2014, https://abundancenc.org/climate-change-gmo-crops-threaten-food-security/.

"How Does Climate Change Impact Water? More Profoundly than You Think." *Water Docs*, Ecologos Environmental Organization, 16 Mar. 2019, https://www.waterdocs.ca/water-talk/2018/9/19/5-ways-climate-change-impacts-water.

Skold, Maria. "5 Reasons Why the Climate Crisis Is a Water Crisis." *SIWI*, 4 May 2022, https://siwi.org/latest/5-reasons-why-the-climate-crisis-is-a-water-crisis/.

"Water and Climate Change." *IUCN*, International Union for Conservation of Nature, 5 Dec. 2018, https://www.iucn.org/resources/issues-briefs/water-and-climate-change.

"Water Cycle." *Water Cycle | National Oceanic and Atmospheric Administration*, 1 Feb. 2019, https://www.noaa.gov/education/resource-collections/freshwater/water-cycle.

"World Water Day 2022." *World Water Day*, UN Water, 2022, https://www.worldwaterday.org/.

Climate Change & the Water Cycle | 1.1 Notes Organizer	**Name: _____**
Instructions: *This organizer is meant for any facts and new information that you find important during the presentation and discussions happening today. This worksheet should be completed and turned in along with the culmination activity at the beginning of next class for a grade.*	
I. Where does our drinking water come from?	• • • • •
II. What is the Water Cycle?	• • • • •
III. Is water related to climate change?	• • • • •
IV. What are the effects climate change has on the water cycle?	• • • • •

V. Impacts of this relationship on the Earth's ecosystem	• • • • •
VI. Impacts of this relationship on the humanity	• • • • •
VII. What are possible solutions to this problem?	• • • • •

Climate Change & the Water Cycle | 1.2 Culmination Activity Name: _____

Instructions: *This is a short writing exercise meant for you to apply the concepts that we discussed in class today. Your task is to write **3-4 sentences** responding to **two** of the four questions listed below. Be sure to specify which question you are answering and provide as much detail as possible. You are allowed to use your graphic organizer to complete this activity.*

Questions:

1. *Who do you think is the most at risk from the impacts of climate change? Why?*
2. *What is the difference between climate change and climate variability? Provide examples.*
3. *Why is it important to act now? Have you recently read about any instances where climate change is already causing problems?*
4. *What piece of information were you most surprised by? Did it make you want to take action?*

This activity is due along with your complete graphic organizer for a grade at the beginning of next class.

Climate Change & the Water Cycle | 1.1 Notes Organizer **ANSWER KEY** **Note:** This is not a comprehensive answer key; students who write down relevant facts to the presentation given during class will receive full credit. However, one of the main purposes of this lesson is to inform students so they will be able to act as these problems become more of a threat to humanity each day. If a student is missing a key idea/concept, please write it in the corresponding box before giving the organizers back to the students.	
Instructions: *This organizer is meant for any facts and new information that you find important during the presentation and discussions happening today. This worksheet should be completed and turned in along with the culmination activity at the beginning of next class for a grade.*	

I. Where does our drinking water come from?	• Surface water: ⅔ of our freshwater supply
	  ○ Comes from rivers, lakes, streams that are replenished by precipitation
	  ○ Water is sent to be decontaminated before it can be consumed by the public
	• Groundwater: ⅓ of our freshwater supply
	  ○ Stored under the ground in aquifers
	  ○ Also replenished by precipitation
	  ○ Only accessible at natural springs or wells
	• The availability and quality of both groundwater and freshwater sources are being threatened by climate change

II. What is the Water Cycle?	• The water cycle has multiple phases: solid, liquid, and gas • Related to all the major climate systems: clouds, air, oceans, lakes, snow, vegetation • Water is continuously moving through atmosphere in forms of weather and climate • Interconnectedness - water is crucial for meeting the needs of society and ecosystems • If this cycle is altered or jeopardized it can threaten the economy, human health, ecosystems, etc.
III. Is water related to climate change?	Video Interview • Water is one of the driving forces of climate • Floods, droughts, storm, melting glaciers - 75% of natural disasters between 2001-2018 were water related, their frequency and intensity are only expected to increase with climate change • Good water management, governance, and investments are necessary • Water is a connect where effects can be universal • Nature plays a strong role in creating water storage and protection from floods
IV. What are the effects climate change has on the	• Rising temperatures mean that more evaporation will take place in the sea and other bodies of water • Warmer air holds more water vapor meaning more intense

water cycle?	rainfall • Intense storms mean more flooding of rivers or streams - this does not dampen soil • Since land is not being dampened increased risk of drought as well • These effects relate directly to water scarcity and conflict
V. Impacts of this relationship on the Earth's ecosystem	• Higher amounts of greenhouse gasses in the atmosphere mean that the heat being emitted cannot escape into space, so it gets absorbed in the top layer of the ocean causing increased melting of ice sheets, ice caps and glaciers • Flooding will hurt coastal communities and infrastructure as well as threaten freshwater reserves that will be contaminated by saltwater from the ocean • Increased evaporation means that surface water supplies will be less reliable - groundwater sources will be heavily relied upon • More frequent floods affecting agriculture, longer period of soil moisture deficit • More extreme weather events already occur because of climate variability • Due to climate change leads to more variability
VI. Impacts of this relationship on humanity	*Water Scarcity:* • Water stress mean that a nation has used 25% or more of their freshwater supply • As disasters and rising temperatures destroy or contaminate our water supplies there will be less freshwater available for the continually growing population • Changes to water cycle make access to safe drinking water harder, especially for children • Water is part of the solution to climate change - adapting will protect children's health and save lives • By using water more efficiently and transitioning to solar powered water systems will reduce greenhouse gasses and further protect children's futures • Between 43%-50% of population will be living in water scarce countries by the end of the century *Water Cooperation:* ◦ 80% of the world's rivers cross national boundaries ◦ As climate change increases volatility of the water system, it is important to make sure international water

	agreements are upheld to ensure the wellbeing of every person

VII. What are possible solutions to this problem?	• Adaptation plans that prioritize water management which reduces vulnerability and increases resilience to safeguard enough water to sustain a projected population of 10 billion by 2050 while mitigating the effects of climate change
	Solutions:
	• Nature based solutions can optimize built infrastructure
	  ○ Mangroves to protect shorelines from storms, lakes storing large water supplies and floodplains absorbing excess runoff, increasing water and energy efficiency, wastewater reuse or wetland protection
	• Develop climate resilience: diverse economies and landscapes absorb shocks, capital and innovation, self-organization, and learning
	  ○ The ecosystem provides services such as watersheds that can provide climate resilient development of food and energy sectors
	  ○ Promote better management of water sectors to benefit more people
	• Efforts to reduce greenhouse gas emissions also depend on access to reliable water sources as all mitigation actions need water to succeed
	• More investment needed in hydrological data, institutions and governance, education and capacity development, risk assessment and knowledge sharing.

Climate Change & the Water Cycle | 1.2 Culmination Activity **ANSWER KEY**
Note: This answer key is meant to provide sample responses for each of the four questions students were given the change to respond to. While there is not an exact answer that is expected, the key topics included in the sample response are some of the main points that can be made when responding to the question. Grading is based on answering two questions, providing relevant material from class, and completing the assignment.
Instructions: *This is a short writing exercise meant for you to apply the concepts that we discussed in class today. Your task is to write **3-4 sentences** responding to **two** of the four questions listed below. Be sure to specify which question you are answering and provide as much detail as possible. You are allowed to use your graphic organizer to complete this activity.* *Questions:* 1. *Who do you think is the most at risk from the impacts of climate change? Why?*

2. *What is the difference between climate change and climate variability? Provide examples.*
3. *Why is it important to act now? Have you recently read about any instances where climate change is already causing problems?*
4. *What piece of information were you most surprised by? Did it make you want to take action?*

This activity is due along with your complete graphic organizer for a grade at the beginning of next class.

Possible Response to Question 1: Possible answers could discuss how women, children, ethnic minorities, poor regions, migrants, people with health conditions, etc. will be impacted.

Possible Response to Question 2: Answers should primarily focus on how climate variability includes variations in the climate that are more than just a singular weather event while climate change encompasses those variations that last for a long period of time, decades or more. Examples of climate variability could include natural occurrences such as changes in the air or ocean circulator, volcanic eruptions, etc. Examples of climate change could include longer lasting droughts, rising average temperatures, etc.

Possible Response to Question 3: Answers will vary among students.

Possible Response to Question 4: Answers will vary among students.