

SSI Unit Plan

Lesson Title: Climate Change: The Connection Between Rising Sea Levels and Climate Refugees

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Topic: Climate Change, Global Warming, Sea-Level Rise, Analyzing Data Sources, Climate Refugees/Environmental Migrants

Targeted Grade Level: Middle School/High School, Grades 8-10

Time Needed: 5-6 Class Periods/60 Minute Periods

Subject Integration: Science, Math, Engineering, and Social Studies

Justification: Students will observe authentic data sourced directly from NASA satellites that will act as a precursor to the cause-and-effect relationship between human activities and increasing global temperatures. Students often hear about rising sea levels in the media but may not know exactly what causes this phenomenon and how to mitigate rising levels. Using this data will help engage students in a lesson about data interpretation and analysis, emphasizing the Nature of Science tenet that *Scientific Knowledge is Based on Empirical Evidence*. Analyzing data will help students think about problem-solving strategies and the engineering practices involved (i.e., designing solutions) that address environmental needs on a local and global scale. Furthermore, students will connect how climate is impacting the world's most vulnerable, seriously reducing their quality of life presently and for future generations. Additionally, when students observe and analyze authentic data, it addresses the question students often pose: "Why do I need to learn this?" In particular, analyzing climate data can help students to acknowledge the importance and functionality of becoming scientifically literate to make informed decisions that will ultimately impact the environment and their future.

- **Science:** Students will practice using observations and data to construct explanations about natural phenomena, analyze data and identify trends and patterns (i.e., observing the highest global temperatures have been recorded in the last two decades), and make predictions about future outcomes.

- **Math:** Students will use algebra to calculate the rate of sea-level change between 1993-present as part of data analysis
- **Engineering:** Students will design a solution to decrease global temperature rise or to protect land and freshwater supplies from highly salinated seawater.
- **Social Studies:** Students will complete a final project exploring the following essential questions:
 - What are the climate change-related problems that threaten the existence of some regions in the world?
 - What are the challenges faced by climate refugees/environmental migrants?
 - What are the measures/policies that governments can adopt to tackle the challenges of climate-related human migration?

Standards

NGSS Performance Expectations:

MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth's systems.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts:
Constructing Explanations and Designing Solutions	<i>ESS3.D: Global Climate Change</i>	<i>Stability and Change</i>

<p>Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.</p> <ul style="list-style-type: none"> Apply scientific principles to design an object, tool, process, or system. <p>Asking Questions and Defining Problems</p> <p>Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.</p> <ul style="list-style-type: none"> Ask questions to identify and clarify evidence of an argument. <p>Analyzing and Interpreting Data</p> <p>Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.</p> <ul style="list-style-type: none"> Analyze data using computational models in order to make valid and reliable scientific claims. <p>Developing and Using Models</p>	<ul style="list-style-type: none"> <i>Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.</i> <p>ESS1.B: Earth and the Solar System</p> <ul style="list-style-type: none"> <i>Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary)</i> <p>ESS2.A: Earth Materials and Systems</p> <ul style="list-style-type: none"> <i>The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.</i> <p>ESS2.D: Weather and Climate</p> <ul style="list-style-type: none"> <i>The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection,</i> 	<ul style="list-style-type: none"> <i>Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.</i> <p>Cause and Effect</p> <ul style="list-style-type: none"> <i>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</i>
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Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).

- Use a model to provide mechanistic accounts of phenomena.

absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.

ESS3.C: Human Impacts on Earth Systems

- *Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.*
- *Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.*

Common Core State Standards:

Math:

CCSS.MATH.CONTENT.5.G.A.2

Represent real-world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

CCSS.MATH.CONTENT.7.RP.A.2.B

Identify the constant of proportionality (unit rate) in tables, graphs, equations, diagrams, and verbal descriptions of proportional relationships.

CCSS.MATH.CONTENT.HSF.IF.B.6

Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.

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. (HS-ESS3-5)

RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms. (HS-ESS3-5)

RST.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. (HS-ESS3-5)

Measurable Student Learning Objectives:

Students will be able to:

- Recall prior knowledge related to sea level and sea-level rise
- Explore and analyze data and graphs that indicate sea level is rising
- Calculate the rate of sea-level change
- Investigate and explain the causes of sea-level rise
- Apply new knowledge to understand how their actions impact sea level rise and climate change
- Design a solution to decrease global temperature rise or to protect land and freshwater supplies from highly salinated seawater

- Apply research skills to investigate and discuss the challenges faced by climate refugees and to propose policies to handle the challenges posed by climate change-related migration

Nature of STEM:

This lesson addresses two fundamental tenets of the nature of science:

1) *Scientific Investigations Use a Variety of Methods*

- Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
- New technologies advance scientific knowledge.

and

2) *Scientific Knowledge is Based on Empirical Evidence*

- Science knowledge is based on empirical evidence.
- Science arguments are strengthened by multiple lines of evidence

Engaging Context/Phenomena:

Students will observe three short videos produced by NASA throughout the lesson to engage them in critical thinking surrounding climate change's cause and effect nature. The first video, "[Watching Sea Level Rise from Space](#)," will be shown as an initial hook for the lesson to introduce the phrase "sea-level rise" and show, through satellite imagery, how sea level has changed over the last two decades. In the next video, "[NASA's Earth Minute: Sea Level Rise](#)," the causes and effects of global warming are addressed, and proposed solutions to stymie land and sea ice melt are touched upon. In the last video, "[NASA's Earth Minute: Gas Problem](#)," the excessive production of greenhouse gases is identified as a major contributor to global warming, specifically carbon dioxide's role in increasing global temperatures.

Data Integration:

Students will observe authentic [Sea Level](#) and [Global Temperature](#) data sourced directly from NASA satellites in this lesson. The data source for Sea Level evidence provides two different graphs: the first represents sea height variation per millimeter over time (1995-present) and the second provides sea-level change per millimeter over time (1900-present) with additional information regarding the factors that have contributed to the increase (i.e. Mountain Glacier melt) and decrease (i.e. building of dams) in sea level height. Both graphs show an upward trend in data, making it easy for students to identify a pattern of increase in sea level height over time and to observe that melting ice sheets and glaciers have added to this increase. Naturally, students will begin to question the cause of the phenomenon, leading them to explore the second data source on Global Temperature which provides ocean-land temperature changes over time relative to 1951-1980 average temperatures and a time series video showing global surface temperature changes over time. Analysis of these data will give students an opportunity to identify trends and patterns (i.e. observing the highest global temperatures have been recorded in the last two decades), make predictions about future outcomes, and consider the underlying causes of global temperature increase.

Differentiation of Instruction:

- Global Warming [Demonstration/Video](#) for students that may struggle with the concept of “heat capacity” or have difficulty visualizing how Earth’s oceans are absorbing most of the heat due to trapped greenhouse gasses.
- Provide a scaffolded worksheet of increasing difficulty to guide students through the data analysis needed for this lesson.
- Think-Pair-Share for data analysis: help students with lower math or critical thinking skills; allow students to rephrase or reframe their thinking; first answer questions alone, then partner up and share ideas, then share with a larger group/class on a giant post-it.

Real-life Connection:

My current students live in NYC and the surrounding areas that are vulnerable to flooding and sea-level rise. Many students and their families were directly impacted by Hurricane Sandy and have a vested interest in learning why certain geographical areas are more prone to flooding and sea-level rise.

Possible Misconceptions:

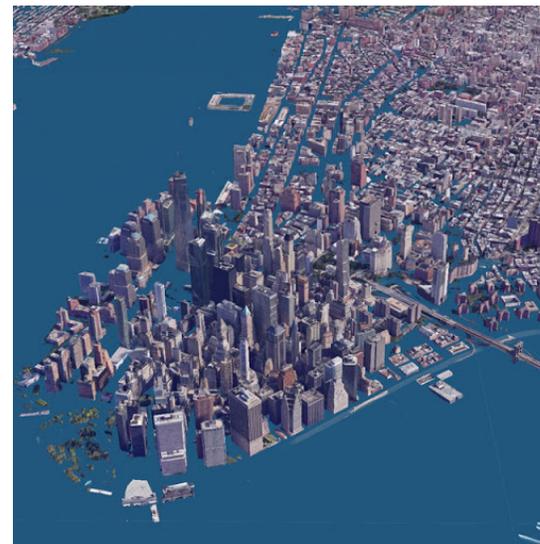
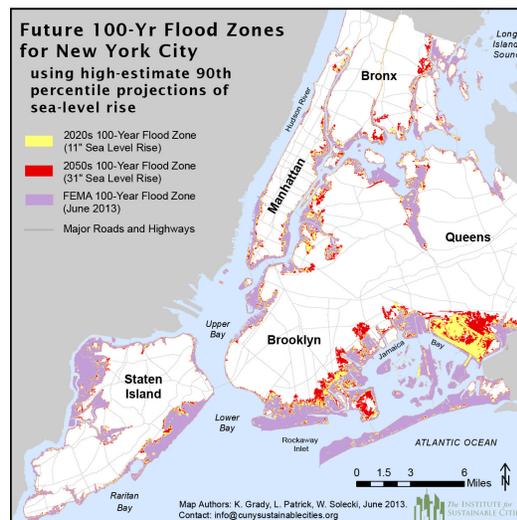
Many possible misconceptions surrounding climate change may come up during this lesson. Below are three major misconceptions that can affect student learning:

- Weather and climate are the same.
 - Students will need a clarification of the difference between weather and climate. Weather is the day-to-day variations in atmospheric conditions, while climate is the average background within which weather occurs.
- Climate has changed and evolved throughout Earth's history; therefore, what the earth is experiencing is normal.
 - Over at least the last 650,000 years, temperatures and carbon dioxide levels in the atmosphere have increased and decreased in a cyclical pattern. However, none of the natural causes of climate change can fully explain the climate changes we are seeing today, as evidenced by data (greenhouse gases are at record levels in the atmosphere).
- All types of air pollution are contributing to global warming.
 - Most industrial pollutants are not greenhouse gases that get trapped in the atmosphere. A major contributor to global warming is carbon dioxide, which is released by the burning of fossil fuels (coal, oil, & gas).

Lesson Procedure:

5E Model	5E Objectives
<u>Engage</u>	Procedure: Day 1 1. Teacher will ask students what they know about climate change and global warming <ul style="list-style-type: none">a. students can turn-and-talk with a partnerb. students will then write their ideas on a T-Chart on large chart paper/front board

- c. teacher will read out student answers without insinuating what is a correct or incorrect answer
2. Use student answers to pivot into some of the effects of global warming & climate change
 - a. students will eventually list sea level rise as an effect of global warming; if they do not, teacher can use guiding questions
3. Students will complete the K & W sections of their KWL chart (on worksheet)
4. Students will watch the video clip "[Watching Sea Level Rise from Space](#)"
5. Teacher elicits students' ideas about sea-level rise through guiding questions on the worksheet:
 - a. What is sea level rise?
 - b. What causes sea level rise?
 - c. Do we have to be concerned about it in our lifetime?
 - d. How do scientists track or measure sea level rise globally?
6. Students will have a few minutes to respond to the above questions individually through writing, then will discuss the questions in a Think-Pair-Share with a partner.
7. Teacher will then lead a class discussion to summarize the major topics of the video. Partners can share what they discussed:
 - a. Sea level rise - cause and effect relationships
 - b. Use of satellite data to track climate change and global warming
 - c. Global concerns and specific concerns of living in/around NYC area
 - d. **For question #3**→ remind students that we are sharing our thoughts and that this is not a debate; teacher can further explain, that as the unit progresses and students acquire more scientific facts and data, their answer to question #3 may change over time.
8. Show Future 100 Year Flood Zones in NYC and Google Earth Sea Level Rise and Fate of Coastal Cities picture. Give students time to observe, reflect, and pose their own questions.

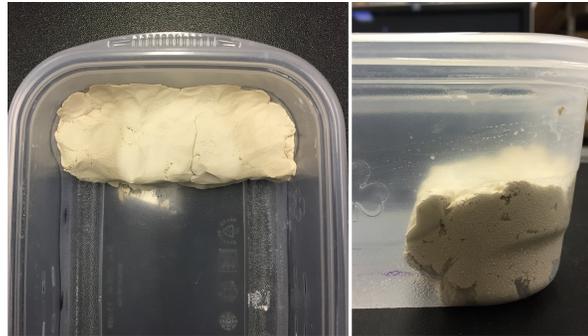


9. Wrap-up: Students share out observations, questions, and inferences.
- Key observations may include: most flood zones are near the water, southern Brooklyn and Queens have large areas of flood zones, students may observe that they live in a flood zone, lower Manhattan (where our school is located) is in a flood zone, but northern Manhattan is not.
 - Key questions may include: Where are JFK and LGA airports located? Were areas in purple more affected by Hurricane Sandy? How severe is the flooding in purple areas? Does the geography of the land differ in flood zones vs non-flood zones?
 - Key inferences may include: Northern Manhattan has hilly terrain and is at a higher elevation than lower Manhattan and therefore, is less vulnerable to flooding; Many of the coastal areas in Southern Brooklyn and Queens contain beaches or marshes and are less elevated than Central Brooklyn or Queens, and therefore, are more vulnerable to flooding.

	<p>Formative Assessments: video guide worksheet summary section</p> <p>Standards Addressed: MS-ESS3-5</p> <p>Modifications: Options for completing work (independent, pair, whole-class discussion); visual aids on worksheet & posted on the board</p> <p>Resources:</p> <p>Video Link: https://youtu.be/z2UKvrU5rOk</p> <p>Video Guide Worksheet: google link</p> <p>HW/Additional Reading: Article “Climate Effects on NYC May Move Faster Than Previously Forecast”</p>
<p><u>Explore</u></p>	<p>Procedure: Day 2</p> <ol style="list-style-type: none">1. Review topics from Day 1 discussion and activities:<ol style="list-style-type: none">a. What is sea level rise?b. What are the possible causes of sea level rise? 2. Teacher explains that students will conduct an experiment to learn how melting ice contributes to sea-level rise.<ol style="list-style-type: none">a. Ask students the following questions to engage their thinking:<ol style="list-style-type: none">i. Where is there a lot of ice in the world?ii. Is the ice on land or water?iii. Will one or both cause sea levels to rise when they melt? 3. Students will record their prediction about which type of ice, sea, land, or both will cause sea levels to rise on their data sheet.

4. Students will work in groups of 3-4 to carry out the experiment.
 - a. Each group will receive:
 - i. 2 clear, plastic food storage containers (6in x 6in)
 - ii. 2 sticks modeling clay (enough to fill a quarter of each container 1-2 inches)
 - iii. tray of ice cubes
 - iv. ruler
 - v. large beaker of water

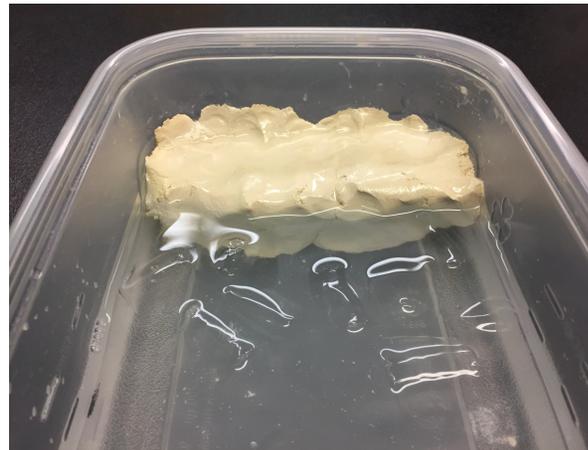
5. Students will then set up the experiment:
 - a. Press equal amounts of clay into one side of each plastic tub, making a smooth, flat surface representing land rising out of the ocean.



- b. In one tub, place as many ice cubes as possible on the flat clay surface. This represents land ice.



- c. In the other tub, place the same number of ice cubes on the bottom of the tub, next to the clay. This represents sea ice.
- d. Pour water into the sea-ice container until the ice floats. Be sure no ice is resting on the bottom of the tub. The water shouldn't be higher than the land level.



- e. Without disturbing the ice cubes, pour water into the land-ice container until the water level is about equal to the water level in the sea-ice container.



- f. Using the ruler, measure the water level (in millimeters) in each tub and record the data on the student data sheet.
- g. You can mark the water level with a marker on the outside of the tub, but if the containers are reused, they will have the marks from the previous group. Another way to mark the water level is to mark a line in the clay using a pencil or other object.
- h. At regular intervals, measure the water level and record it on the data sheet. Compare the water level with the marked line in the clay. Allow the ice in both tubs to melt completely.
- i. Use the measurements recorded on the data sheet to create a line graph representing the water level in each tub.
6. Wrap-Up: Exit Slip or Teacher will ask the following discussion question to the whole class:
- In which container did the water level rise more?
 - How does this compare to your prediction?
 - Why do you think this occurred?
 - In what way is this related to global sea-level rise?

	<ul style="list-style-type: none">• Does the melting of Earth’s glaciers contribute to sea-level rise? How about the melting of icebergs? <p>Modifications: pictures of each step of the experiment complement the written procedure; mixed grouping for lab groups.</p> <p>Standards Addressed: HS-ESS2-4</p> <p>Formative Assessment: HW: lab analysis and conclusion questions</p> <p>Resources:</p> <p>Lab Materials (see above)</p> <p>Lab Sheet (instructions & background) & Data Sheet (<i>adapted from JPL’s “What’s Causing Sea-Level Rise? Land Ice Vs. Sea Ice” Activity</i>)</p>
<p><u>Explain</u></p>	<p>Procedure: Day 3</p> <ol style="list-style-type: none">1. Teacher will review topics from Day 2 lab:<ol style="list-style-type: none">a. What type of ice contributes to sea-level rise, land, sea, or both?<ol style="list-style-type: none">i. Student lab data should show that melting land ice, and not sea ice, contributes to sea-level rise.ii. Some student groups may have contradictory results - if this happens, the teacher should elicit reasons for this from students and include a quick discussion regarding random and systematic errors in science investigationsb. What are examples of land ice? (<i>polar ice caps at North & South Pole and glaciers</i>)

2. Show the video: [NASA's Earth Minute: Sea Level Rise](#). Teacher will elicit student responses to the question: How do we know sea levels are rising? (students will responses will vary but should mention satellite data, direct measurements, repeat photography)
3. Explain to students that they will examine authentic data generated by NASA satellites to identify patterns and trends in sea level rise data.
4. Have students work in pairs to complete the problem sets on the “Analyzing Sea Level Rise” Worksheet; students will need access to a laptop (one per pair) to view the data on NASA’s website (links are embedded in the worksheet).
 - a. Teacher will review mathematical concepts of rate and slope before students begin.
 - b. Students will use the Sea Level Rise graphs to answer questions 1-7 on the worksheet.
 - c. Teacher will check student understanding along the way - periodically pausing student work to come together for larger class discussion
5. Next, students will analyze the [line graph for average global temperatures](#) and complete questions 8-10 on the worksheet.
6. Wrap-Up Activity:
 - a. Each pair of students will partner with another pair to create a group of 4
 - b. Each new group will be assigned 1-2 questions from the worksheet (for smaller classes, consider assigning more questions per group)
 - c. Each group will become “experts” in their assigned questions and act as the “teacher” to lead the rest of the class in a review
 - i. Groups will have 10-15 minutes to prep

	<ul style="list-style-type: none">ii. Groups will expand upon their answers to offer a deeper explanation for their answers to each questioniii. Groups can use NASA website to further their understandingiv. Each group will present and explain in the order of the worksheet questions <p>Modifications: mixed grouping; scaffolded worksheet of increasing difficulty to guide students through the data analysis needed for this lesson.</p> <p>Standards Addressed: HS-ESS3-5, CCSS.MATH.CONTENT.7.RP.A.2.B, CCSS.MATH.CONTENT.5.G.A.2, CCSS.MATH.CONTENT.HSF.IF.B.6</p> <p>Formative Assessments: Informal assessment of group answers and explanations of Wrap-Up Activity</p> <p>Resources: Video: NASA's Earth Minute: Sea Level Rise Student Worksheet: Analyzing Sea Level Rise</p> <p>Students will need access to a laptop or teacher can print out Sea Level Rise and Global Temperature graphs for students</p>
<p><u>Elaborate</u></p>	<p>Procedure: Day 4 and 5</p> <ul style="list-style-type: none">1. Show the video: NASA's Earth Minute: Gas Problem. Teacher will elicit student responses to the following questions: What can be done to control the amount of greenhouse gases in our atmosphere? What is being done in our city to prevent global temperatures from rising?2. Teacher will explain to students that they will design a “green” (sustainable) city.<ul style="list-style-type: none">a. Teacher will share Green Cities Google Slides to elicit student design ideas

	<ol style="list-style-type: none">3. Teacher will share guidelines and planning documents with students4. Students will complete the Green City Planning worksheet individually or with a partner5. Wrap-Up: Teacher will conference with each student about their plans (this will likely need to happen on Day 5)6. Students will complete planning worksheet for HW (if needed), edits their designs, and prepare to share their design ideas in the next class (Day 6) <p>Modifications</p> <p>Standards Addressed: MS-ESS3-3</p> <p>Formative Assessments: Conference with each student/pair of students to give feedback about their preliminary designs</p> <p>Resources:</p> <p>Video: NASA's Earth Minute: Gas Problem</p> <p>Green Cities Google Slides</p> <p>Green Cities Guidelines & Planning Document (adapted from Resources for Thinking: My Green City)</p>
<p><u>Evaluate</u></p>	<p>Procedure: Day 6</p> <ol style="list-style-type: none">1. Students will share their design ideas from Days 4 & 5's Green City Activity in small groups.2. Teacher will explain the final evaluation for this unit: a climate change research project to showcase student learning. <p>Step 1: Students will continue to research climate change independently using the Internet and/or books.</p> <p>Step 2: Students will create a poster board or PowerPoint presentation to display their learning and will include the following criteria.</p> <p><input type="checkbox"/> Title – The name of your topic</p>

- Description** – What is climate change? How was it first discovered?
- Diagram** – Draw and label a diagram of the greenhouse effect
- Evidence** – How do we know that the climate is changing?
- Causes** – What are the causes of climate change?
- Effects** – How does climate change impact the environment? Specifically, how does climate change impact vulnerable communities living in environmentally fragile areas?
- Countries** – Which countries emit the most greenhouse gasses? Why?
- Prevention** - What can people do to mitigate the impact of climate change?
- Significance** – How will the world look if we do not address climate change?
- Personal Connection** – How do you feel about what you learned? If you were a government leader, what policies would you propose to handle the challenges posed by climate change-related migration
- References** – Where did you find your information? (Websites, Books, etc.)
- Project Extention (Optional):** Design a solution to decrease global temperature rise or to protect land and freshwater supplies from highly salinated seawater.

Step 3: Students will present their project to the class (5-10 minutes).

3. Teacher will distribute and explain project guidelines, planning documents, and assessment rubric.
4. Students will begin research in class; teacher can circulate to address clarifying questions as they pop up
5. Students will complete the project at home and present it in two weeks.

Modifications Options are provided for the project to address various learning styles

Standards Addressed: RST.11-12.1, RST.11-12.2, RST.11-12.7

Summative Assessments: Project rubric/graded assessment

	Resources Climate Change Project Guidelines & Research Template Climate Change Countries Lists Project Rubric

Teacher Background:

The following links can provide teachers with a deeper background regarding the major concepts needed for this lesson:

[JPL's Educator's Guide: Lessons in Sea Level Rise](#)

[JPL's What's Causing Sea Level Rise? Land Ice vs Sea Ice? Lab](#)

[UNESCO Sustainable Cities and Communities Resources for Educators](#)

[Green Cities of Europe](#)

[EPA's Pollution & Air Quality Guide](#)

[UNHRC Climate Change and Disaster Displacement](#)