MODULE 4: COMMUNITY PLANNING

MODULE & LESSON TIMING: There are 3 lessons in Module 4. Each lesson should be able to be completed in one class period, with student readings before or during.

WHAT TO EXPECT: Module 4 examines sea-level rise resilience by "putting it all together" through community planning.

TEACHER BACKGROUND RESOURCES:

Videos

- Introductory case study video "Master Planning in South Padre Island, Texas" (5-minute video)
  - Alabama: https://vimeo.com/318492225
  - Mississippi: https://vimeo.com/322234446
- Planning for Rising Seas: Northern Gulf Sea-Level Rise (5-minute video)
  - https://vimeo.com/323815494
- Science Friday segment on flooding
  - Cities are starting to rethink their how water is collected, stored, and conserved and how they can make their communities more resilient. Engineers and architects are looking to nature for inspiration by replacing dams and pipes with green roofs and other green infrastructure. City planners are designing parks based on how the natural ecology of the landscape handled the water. Instead of trying to hold back the floods, they're welcoming the water and finding ways to turn it into fresh, useable water.
  - https://www.sciencefriday.com/segments/turning-flood-water-into-freshwater/ (34 minutes)
- Video, Florida Keys road adaptation planning project (8 minutes):
  - https://www.youtube.com/watch?v=qJ7xOP_BAeo&feature=youtu.be

Readings

- Introduction to Stakeholder Participation, NOAA's Office for Coastal Management:
  - https://coast.noaa.gov/data/digitalcoast/pdf/stakeholder-participation.pdf

- Flooding is the natural hazard with the greatest economic and social impact in the United States, and these impacts are becoming more severe over time. Catastrophic flooding from recent hurricanes, including Superstorm Sandy in New York (2012) and Hurricane Harvey in Houston (2017), caused billions of dollars in property damage, adversely affected millions of people, and damaged the economic well-being of major metropolitan areas. Flooding takes a heavy toll even in years without a named storm or event. Major freshwater flood events from 2004 to 2014 cost an average of $9 billion in direct damage and 71 lives annually. These figures do not include the cumulative costs of frequent, small floods, which can be similar to those of infrequent extreme floods. Dr. Lauren Alexander Augustine discussed some of the findings of the National Academies of Sciences, Engineering, and Medicine's recent report "Framing the Challenge of Urban Flooding in the United States."
    - National Academies of Sciences, Engineering, and Medicine. 2019. Framing the Challenge of Urban Flooding in the United States. Washington, DC: The National Academies Press. https://doi.org/10.17226/25381. https://www.preventionweb.net/files/73798_25381.pdf
    - There are four dimensions of urban flooding:
        - 1. The physical dimension represents the built and natural environments.
        - 2. The social dimension represents the people, where they live, who in the community is impacted, what those impacts look like, etc.
        - 3. The information dimension looks at a variety of issues such as what data are needed to understand the flood risk, how to communicate risk, how people interpret information about risk, etc.
        - 4. The actions and decisions dimension considers what needs to be done about urban flooding, how decisions are made, how flooding is managed, etc.
- Article on flooding "The Growing Thread of Urban Flooding: A National Challenge": https://cdr.umd.edu/sites/cdr.umd.edu/files/urban-flooding-report-online.pdf.
    - Galloway, G. and Brody, S. 2018. The Growing Threat of Urban Flooding: A National Challenge. University of Maryland, College Park and Texas A&M University, Galveston Campus. Accessed February 3, 2020.
    - This report was based on a national survey of municipal flood and stormwater managers and professionals, and found:
        - 83% of respondents experienced urban flooding in their communities.
        - 65% of respondents indicated that most of the damages from these floods were not covered by the National Flood Insurance Program (NFIP) because the community was located well outside the areas of the FEMA floodplains and located in areas that were not considered at risk for floods.
        - 41% of respondents indicated that their communities do not have funding to address their urban flooding problem.
        - 32% of respondents stated that there is a lack of political will to address the urban flooding problem.

        - Respondents believed only 34% of elected officials and 28% of the public were concerned about urban flooding in their communities.
    - Some of the report's conclusions include:
        - Urban flooding is a local government issue, but it is everyone's problem. How do we put communities in a better position to be able to deal with urban flooding?
        - The division of responsibility for urban flooding is fragmented. There is too much stove-piping within government and between agencies and organizations. There is no coordinated approach for dealing with urban flooding.
        - Infrastructure is aging and inadequate, and it is getting worse.
        - There is no federal agency charged with coordinating the federal support of urban flooding.
        - The economic and social impacts of urban flooding are immense. The lowest income groups are being hit hardest.
        - Government is not communicating the urban flooding risk very well, and the data needed to understand the risk are lacking.
- Article about sea-level rise community impacts "Norfolk Wants to Remake Itself as Sea Level Rises, but Who Will Be Left Behind?" https://insideclimatenews.org/news/21052018/norfolk-virginia-navy-sea-level-rise-flooding-urban-planning-poverty-coastal-resilience/
- A discussion surrounding the language of sea-level driven migration and why our words matter. "Reframing the Language of Retreat" https://eos.org/opinions/reframing-the-language-of-retreat
- Article "Flooded: How Natural Disasters Lead to Predatory Lending in the Rio Grande Valley" https://shelterforce.org/2020/11/06/flooded-how-natural-disasters-lead-to-predatory-lending-in-the-rio-grande-valley/
- Article about the Pointe-au-Chien Tribe
    - https://gulfofmexicoalliance.org/2020/09/pointe-au-chien-tribe-a-success-story/
- Article "Protection for the Rich, Retreat for the Poor," How the United States' implementation of climate change adaptation programs is exacerbating inequality and breeding a new form of climate gentrification: https://www.hakaimagazine.com/news/protection-for-the-rich-retreat-for-the-poor/
- Article "California Has A New Idea For Homes At Risk From Rising Seas: Buy, Rent, Retreat" https://www.npr.org/2021/03/21/978416929/california-has-a-new-idea-for-homes-at-risk-from-rising-seas-buy-rent-retreat

RECOMMENDED CURRICULUM CITATION:

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4.1 Sea-Level Rise Risk & Reward

AGE RANGE
9th—12th grade

TIME REQUIRED
70 minutes

ACTIVITY OVERVIEW
Engage: Discussion Question

Explore: SLR Risk & Reward

Explain: Reflections

Elaborate: Adaptation Pathways Reading

Evaluate: Discussion Question

MATERIALS
Dice (one per group)
Candy or tokens (>5 per student)
Group Set-Up page
Group Worksheet

BASED ON:
"Game of Futures" by Dani Boudreau Tijuana River National Estuarine Research Reserve

LESSON TOPIC: Integrating sea-level rise resilience into planning.

ACTIVITY SUMMARY: Students will play a dice game that simulates making adaptations to plan for future sea-level rise.

OBJECTIVES:

Students will be able to:

- Understand the need to plan adaptation strategies with location-specific sea-level rise information.
- Determine if adaptation strategies are effective at reducing impacts under different climate scenarios.

LESSON BACKGROUND: The dice game sets up student groups as communities. Each student makes individual choices that may impact the whole community. Through the gameplay, students decide how much they will prepare their home for sea-level rise. The future sea-level rise impact is determined by rolling the dice. As the game progresses, students pay money if their adaptation strategy did not protect their home from sea-level rise impacts, but students will also have an opportunity to update their strategy.

The game includes a version of an insurance payout. Homeowners or renters insurance covers losses and damages to an individual's residence. The individual pays a certain amount based on the value of their home to the home insurance company each month, called the premium. In

return, the insurance company agrees to pay a certain amount of money to cover expenses if there is a catastrophic event. In the case of a catastrophic event, the homeowner files a claim with the insurance provider. The insurance provider sends someone to assess the damage, and after filing paperwork, the homeowner will receive a payment to cover damages.

The student reading builds off the game by introducing the concept of adaptation pathways. The reading outlines the technique used to mitigate damage from future sea-level rise impacts by utilizing multiple solutions that build on one other. These adaptation strategies are organized into a pathway that can be followed, and additional mitigation actions added as conditions change. This becomes a proactive planning tool to add policy change and mitigation actions by following the observed sea-level rise rather than projections. Adaptation strategies are not one size fits all but they can build on previously implemented strategies. By using numerical modeling of physical processes, like wind and waves, scientists can get an idea of how adaptation strategies will behave in a future climate. There is uncertainty regarding the impacts of sea-level rise, but we can still plan for the future by effectively considering the uncertainty and preparing to respond to a range of scenarios.

The dice outcomes may seem predictable in the game, and that is because some outcomes, like sea-level rise scenarios, are more likely than others. Scientifically speaking, the range of sea-level rise scenarios cover all scientifically plausible scenarios. Having a large range of sea-level rise scenarios does not mean that scientists do not know what they are doing. It shows the range of possible outcomes. There are three major reasons for the scenarios. The first is that we do not know how much carbon will be in the atmosphere because the rate of global carbon emissions changes with policies put in place by different governments. The second is the natural variability built into the scenarios. The third is that scientists are still studying ice sheet melt, and the models used to measure the volume of ice sheets and their rate of melting is relatively new and getting more accurate constantly. With these reasons in mind, the range of sea-level rise scenarios shows the range of scientifically possible scenarios for future sea-level rise with low scenarios following a low-end range of natural variability and an extreme scenario following catastrophic ice melt. *The Module 3 lesson 3.2 Assets at Risk involves a discussion on sea-level rise projections that can be connected to this lesson.*

Just as with the dice, is it helpful to plan for sea-level rise by considering scenarios based on their probabilities of occurring. The likelihood of each sea-level rise scenario depends in part on the amount of carbon gas in the atmosphere. Carbon emission scenarios, also known as Representative Concentration Pathways or RCPs, represent different potential futures based on policies and actions of people globally. The table below explores the probability of each sea-level rise scenario under three different RCPs: RCP2.6 is a dramatic reduction of carbon currently in the atmosphere; RCP4.5 is a modest decrease in global carbon emissions; and RCP8.5 is continuing on the current global emissions trajectory. As stated above, the scenarios, low through extreme, cover the range of scientifically plausible scenarios. Probabilities help us understand the likelihood

of each scenario occurring. For example, under RCP8.5, it is 100% likely that we will exceed the Low scenario by 2100, while there is a very low probability (0.1% chance) that we will exceed the Extreme sea-level rise scenario by 2100.

Probabilities of occurrence help determine which scenario best supports your risk tolerance in planning. For example, although the High scenario has a low probability of occurring, you may want to plan for it when protecting long-term investments with low risk-tolerance. For instance, a military base or water treatment facility would have a low risk-tolerance because they serve critical functions to a large number of people, have interdependent systems with other critical services, and cannot be easily moved or adapted to future conditions once built

Likelihood of sea-level rise scenarios:

Global Sea Level Rise Scenario	RCP2.6 dramatic reduction of carbon emissions	RCP4.5 modest reduction in carbon emissions	RCP8.5 no change in carbon emissions
Low	94%	98%	100%
Intermediate low	49%	73%	96%
Intermediate	2%	3%	17%
Intermediate-high	0.4%	0.5%	1.3%
High	0.1%	0.1%	0.3%
Extreme	0.05%	0.05%	0.1%

Source: Collini et al, 2018

VOCABULARY:

Adaptation	The process of adjusting to new (climate) conditions in order to reduce risks to valued assets.
Adaptation Planning	Preparing a natural or urban area for the effects of climate change with the intention of reducing risk or exposure.
Adaptive Capacity	The ability of a person, asset, or system to adjust to a hazard, take advantage of new opportunities, or cope with change.
Critical Facilities and Services	Man-made structures/improvements which, because of their function, size, service area, or uniqueness, are paramount to day-to-day function (e.g., hospitals, power plants, wastewater treatment facilities, emergency response, etc.).

Risk Communication	Process of informing people about potential hazards to their person, property, or community.
Social Vulnerability	Risk that a community will lose its ability to maintain social interactions, cultural institutions, and/or a standard of living. Negative impacts on communities due to stresses on human physical, mental, or cultural health, which consider socioeconomic factors like poverty level, access to transportation, and living conditions.

ENGAGE:

Ask students: What do you think about when making an important decision? Is it important to know the possible outcome(s) when you are planning? Would they want to know future sea-level rise when building a beach house?

EXPLORE:

Students will play the Sea-Level Rise Risk & Reward game.

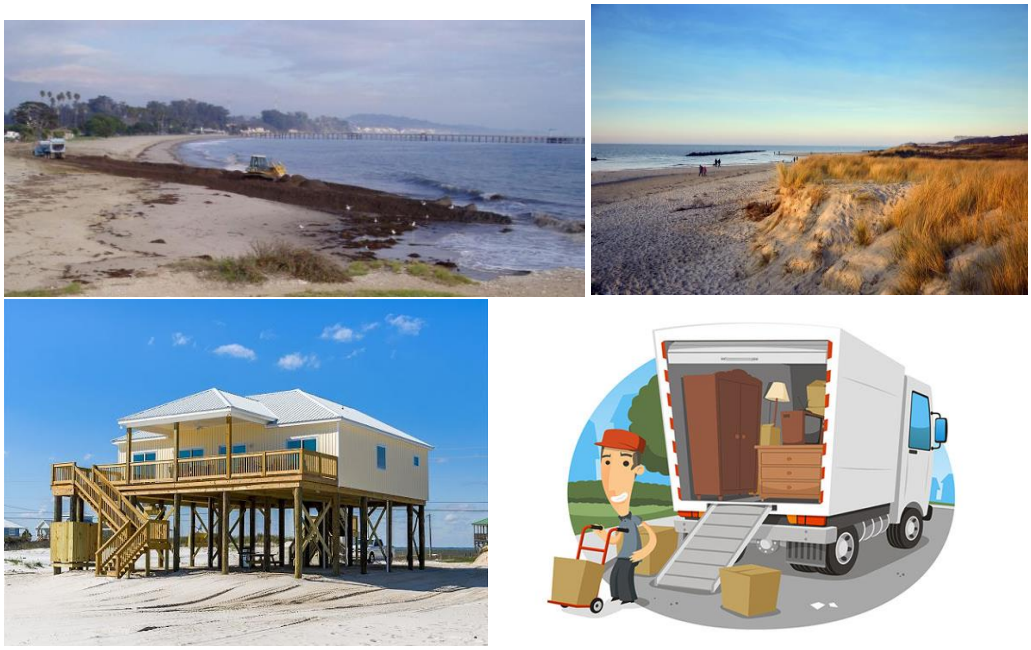
Game Procedure:

1. Divide class into groups of 5. In a group of 5, one player will act as scorekeeper and the others will each get one turn to roll the dice.
    - Note: If you do not use dice in your classroom you can have students use a phone or computer to "roll the dice" by asking Siri to "roll two dice" or the teacher can pre-roll numbers.
2. Each student is given 5 pieces of candy or tokens. This represents the total money an individual has to repair, maintain, or modify the adaptation strategy as climate change is experienced.
3. Each student in a group will choose an adaptation strategy (below) to implement. They are planning to protect their home for approximately the next 30 years, through 2050.

    ADAPTATION STRATEGIES:
    You own your house on the coast. To make your home resilient to sea-level rise you can choose from the following possible options in the short term. Pay the candy/tokens to the bank.

    A. Do nothing (cost = 0 candy)
        - **Teacher talking point:** in this strategy the home is left as is.

B. Nourish the beach in front of your home to accommodate scenario 1 (cost = 1 candy)
    - **Teacher talking point:** nourishing the beach in front of the home replaces sand lost from erosion and this land will act as a barrier to sea-level rise.
C. Build a dune in front of your house to accommodate scenarios 1 & 2 (cost = 2 candy)
    - **Teacher talking point:** a dune with dune grasses will offer protection to the home from erosion and water inundation
D. Elevate your house to accommodate scenarios 1,2 & 3 (cost = 3 candy)
    - **Teacher talking point:** elevating the home raises it above base flood elevation (or higher) and will allow water to come underneath but not impact the home
E. Relocate your house inland to accommodate scenarios 1, 2, 3 & 4 (cost = 4 candy)
    - **Teacher talking point:** the home will be relocated away from the water but still within the community. This allows the home to be protected from sea-level rise impacts but also maintain community social connections and contribute to taxes.



Images: Top left, beach renourshiment; top right, sand dunes; bottom left, elevated house; bottom right, relocation.

4. Player One rolls two dice, once. Determine the scenario outcome (Step 5). Player One's roll affects all students in their group.
    - The probability of the dice sum outcome is linked to the probability of future sea-level rise scenarios for the northern Gulf of Mexico (Mississippi, Alabama, and NW Florida).

- This sea-level rise scenario outcomes in this game are representative of likelihoods with no change in carbon emissions. You may choose to share this with your students when they are selecting Adaptation Strategies.
    1. **100%** Low 0.8ft (~0.2m)
    2. **96%** Intermediate-Low 1.0ft (~0.3m)
    3. **17%** Intermediate 1.5ft (~0.5m)
    4. **1.3%** Intermediate high 2.0ft (~0.6m)

5. The sum of the two dice determines what scenario they are in.

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Year 2050	7	6 or 8	4, 5, 9, 10	2, 3, 11, 12

   Payout!
    a. If students adequately protected their home from the scenario they rolled, they keep their candy/token and get 2 bonus candy/token. The bonus candy/token reflects homeowners saving income.
    b. If students did not adequately protect their home from the scenario they rolled, they pay the bank with 1 candy/token for each level of scenario of difference. (Ex: If they protected to Scenario 1 but rolled Scenario 2, they pay 1 candy/token. If they protected to Scenario 1 but rolled Scenario 4, they pay 3 candies/tokens.)
6. Repeat with Player Two rolling the dice.
7. Before Player Three rolls there is an opportunity for an Insurance Payment. If any of the players lost candy/tokens due to the scenario outcome in Round One, they get to collect one less candy/token than they lost. (Ex: If they paid 1 candy/token, they would not collect insurance. If they paid 3 candy/token, they would collect 2 candy/token from insurance.) This represents the process of insurance payments, where partial damage is covered through insurance and it happens months-years after the damage.
8. Repeat Step 4 with Player Three rolling the dice.
9. There is an opportunity at this point in the game for students to change their original Adaptation Strategy to one of the other 5 choices. **Discuss with students**: Is my strategy effective?
    - Is everyone's strategy still effective with the sea-level rise scenarios?
    - What strategies are successful in the new scenario? Why or why not?
    - If not successful, can it be altered to be effective in the scenario?
10. Repeat Step 4 with Player Four rolling the dice.
11. Players count their remaining candy/tokens.

EXTENSION: There are two game extension opportunities to add to the game. RESOURCE VULNERABILITY starts the game off with each individual having different resources. This option would work well for 1) classes playing a second round or 2) for teachers to use the first time with an advanced class. HIGH-TIDE FLOODING COMMUNITY IMPACT is a game option that allows teachers to add an element into the game while it is currently being played. There are three real life scenarios for teachers to select from.

RESOURCE VULNERABILITY

When the game is played with Resource Vulnerability, individuals in the community start the game with different resources. To determine which players will have limited resources each player will roll one die. The die outcome is the number of candy/tokens that player starts the game with. (Ex: If they rolled a 1, they only get 1 piece of candy/token.)

Social vulnerability is a combination of factors that determine how resilient a community is when confronted by external stresses, potentially from a hazard like sea-level rise. The Social Vulnerability Index (SVI) employs U.S. Census Bureau data to identify communities at higher risk. The SVI ranks on 15 social factors, including poverty, disability, minority status, lack of vehicle access, and crowded housing. These are then grouped into four themes: socioeconomic status, household composition, race/ethnicity/language, and housing/transportation. Our game will rank students randomly and is used as a starting point for discussion of resource vulnerability. The SVI fact sheet can be found online: https://svi.cdc.gov/factsheet.html

HIGH-TIDE FLOODING COMMUNITY IMPACT

When the game is played with High-Tide Flooding Community Impact, the community group must work together to fund infrastructure improvements. This extension can be introduced to the game at any point by the teacher to heighten game-play and stimulate community-level conversations. There are three real-life simulated options below for the teacher to select from. Each of the following community impacts affect everyone regardless of their chosen Adaptation Strategy. The community cost for each improvement is 10 candies/tokens, and this can be divided across individuals however each community group decides, for example, communities may decide that everyone contributes an equal share. In the case that some individuals do not have enough money the community may decide that other individuals cover the difference.

Road Access: The main road to enter the community is inaccessible for one third of the year due to high-tide flooding. Since the flooding blocks access for the whole community, the community must collectively raise the funds to elevate the road.

Storm Water Infrastructure: The storm drains along community roads no longer drain rainwater away fast enough during thunderstorms. Sometimes the storm drains back up with water during a high tide even without a rainstorm. The outflow pipe directs water from the streets into the bay. This system needs to be improved so that the exit point is not covered by water during the tidal cycle.

Power Station: The facility that provides power for the community is vulnerable to storm surge inundation and needs to be relocated. Moving the power station will allow the community to be more resilient to future storms. This relocation will be a partnership between the power company and the community, so the community will help pay a portion of the relocation cost.

EXPLAIN:

Wrap-up and reflections

Begin by determining who the individual and group "winners" are. If multiple people or groups seem to have been successful, begin a discussion around why those individuals/groups were successful.

Discuss with students what lessons were learned throughout the process.

- If you did not choose an expensive adaptation when you had the resources, how did that impact you later in the game? Would you change your strategy if you did it again?
- What strategies seemed to be the most resilient?
- Community vs. individual successes?
- What did you struggle with throughout the game?
- Is the adaptation to relocate an easy choice in real life?
- Was there one scenario that seemed to be particularly difficult for individuals or community?
- Who has the most candy left and why? Even though relocation protects against all scenarios, it also cost the most and may not even have been necessary.
- Do the outcomes seem a little predicable? Is sea-level rise predictable?
    - With this final discussion topic remind them that we have the sea-level rise projections for the range of scenarios from Low to Extreme. We can use this information to make plans for our homes and communities.

Connect to facts:

- Every $1 spent on mitigation funding can save the nation $6 in future disaster costs.
    - National Institute of Building Sciences. Natural Hazard Mitigation Saves: 2017 Interim Report
- For every $1 a private property owner spends installing a living shoreline instead of a bulkhead they will save $6 in avoided maintenance, replacement, and storm repair costs over 60 years.
    - Sicangco, Camille, et al. *Cost-Benefit Analysis of a Small-Scale Living Shoreline Project*. MASGP-21-054
- As sea-level rises, the benefits for installing a living shoreline also rise. Rising seas decreases the lifespan of bulkheads, increasing maintenance cost and replacement frequency.
    - Sicangco, Camille, et al. *Cost-Benefit Analysis of a Small-Scale Living Shoreline Project*. MASGP-21-054

The Sea-Level Rise Risk & Reward game allows students to start thinking about how planning now prepares individuals and communities for future conditions.

ELABORATE:

Students read the excerpt about adaptation strategies. This mirrors the game-play, because as conditions change you can follow the adaptation pathway and make the largest/most expensive adaptations only when they are needed, yet preliminary planning and investment is required for these approaches to work.

Excerpt from Smallegan S. M., Irish, J. L., and van Dongeren, A. R. (2017) Developed barrier island adaptation strategies to hurricane forcing under rising sea levels. Climate Change.

EVALUATE:

Ask students: What is an adaptation pathway? Why is it important to have a mitigation plan that might change?

STUDENT PAGE | Sea-Level Rise Risk & Reward – Group Set-Up

FUTURE SCENARIO NARRATIVES:

1. Low: 0.8ft (~0.2m)
2. Intermediate-Low: 1.0ft (~0.3m)
3. Intermediate: 1.5ft (~0.5m)
4. Intermediate-High: 2.0ft (~0.6m)

ADAPTATION STRATEGIES:

You own your house on the coast. To make your home resilient to sea level rise you can choose from the following possible options in the short term. Pay the candy/tokens to the bank.

A. Do nothing (cost = 0 candy)
B. Nourish the beach in front of your home to accommodate scenario 1 (cost = 1 candy)
C. Build a dune in front of your house to accommodate scenarios 1 & 2 (cost = 2 candy)
D. Elevate your house to accommodate scenarios 1,2 & 3 (cost = 3 candy)
E. Relocate your house inland to accommodate scenarios 1, 2, 3 & 4 (cost = 4 candy)

GAME-PLAY

SEA-LEVEL RISE SCENARIOS:

The sum of the two dice determines what scenario you are 30 years into the future:

	Scenario 1 - Low	Scenario 2 – Intermediate-Low	Scenario 3 - Intermediate	Scenario 4 – Intermediate-High
Year 2050	7	6 or 8	4, 5, 9, 10	2, 3, 11, 12

ROUND PAYOUT:

a. If students adequately protected their home from the scenario they rolled, they keep their candy and get 2 bonus candy.
b. If students did not adequately protect their home from the scenario they rolled, they pay the bank with 1 candy for each level of scenario of difference. (Ex: If they protected to Scenario 1 but rolled Scenario 2, they pay 1 candy. If they protected to Scenario 1 but rolled Scenario 4, they pay 3 candy.)

INSURANCE PAYOUT:

If any of the players lost candy/tokens due to the scenario outcome in Round One, they get to collect one less candy/token than they lost. (Ex: If they paid 1 candy, they would not collect insurance. If they paid 3 candy, they would collect 2 candy from insurance.)

STUDENT PAGE | Sea-Level Rise Risk & Reward – Group Worksheet

	Player 1: *Name*	Player 2: *Name*	Player 3: *Name*	Player 4: *Name*	Player 5: *Name*
Strategy: *Check a box*	☐ A ☐ B ☐ C ☐ D ☐ E	☐ A ☐ B ☐ C ☐ D ☐ E	☐ A ☐ B ☐ C ☐ D ☐ E	☐ A ☐ B ☐ C ☐ D ☐ E	☐ A ☐ B ☐ C ☐ D ☐ E
Round One Roll: _____	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*
Round Two Roll: _____	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*
Insurance Payment If you lost $$ in Round One *Check a box*	☐ No ☐ Yes +_____	☐ No ☐ Yes +_____	☐ No ☐ Yes +_____	☐ No ☐ Yes +_____	☐ No ☐ Yes +_____
Round Three Roll: _____	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*
Strategy change? *Check a box*	☐ No ☐ Yes: _____	☐ No ☐ Yes: _____	☐ No ☐ Yes: _____	☐ No ☐ Yes: _____	☐ No ☐ Yes: _____
Round Four Roll: _____	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*
Final Count:	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*	*Write # of candy*

Adaptation Pathway - Sequential implementation of adaptation strategies as a policy pathway

Due to the uncertainty in future climate conditions, including the amount of sea-level rise and coastal response to those conditions, and due to relative effectiveness of individual strategies for different rates of sea-level rise, it is important to develop a strategic plan that is also adaptive. Haasnoot et al. (2013) describes dynamic adaptive policy pathways: a set of possible actions that may be implemented sequentially and in response to changing conditions. When the current action is no longer able to meet the intended objective, which in this study is to lessen the damage to a coastal community from a hurricane and rising seas, a tipping point is reached and a new action must be chosen.

Using the sea-level rise scenarios and adaptation strategies analyzed in this study, a policy pathway is created for Bay Head (Fig. 5). According to computer modeling simulations, strategy A reduces erosion (i.e., improves habitability) for sea-level rise = +0.2 m but not for sea-level rise = +1.0 m and higher. Strategy A is also the least expensive option in terms of initial costs based on the amount of sediment required to raise the beach (Fig. 2). However, a tipping point is reached as sea levels rise from +0.2 to +1.0 m, and a new strategy must be chosen. The preferred pathway routes to strategy B (Fig. 5) such that, as sea levels rise above +0.2 m, both the beach and dune must be nourished to offer protection from future storms at higher sea levels. Since there is more sediment available on the beach and dunes for transport (Fig. 2), erosion is reduced, island habitability is improved, but initial costs are higher due to the additional sediment required to build the dune. Also, the larger dunes only protect against ocean-side waves and surge, and the back barrier remains vulnerable to flooding and erosion by bay-side surge.

As sea levels continue to rise, back-barrier vulnerability becomes too large and another tipping point is reached. Strategy D is required to continue protection of the island for sea-level rise greater than +1.0 m. Although raising the island is an extreme adaptation strategy, it was implemented in Galveston, TX, USA, a developed barrier island located on the Gulf of Mexico. After a devastating hurricane in 1900, Galveston built a 16-km-long seawall and raised the island by up to 4 m (Bartee 2001). Over the last century, Galveston has survived several strong tropical storms including Hurricane Ike (2008), which has been largely attributed to the seawall and grade raising (Bartee 2001). As sea-level rise increases above 1.0 m in Bay Head, strategy D is the only option considered here that prevents complete erosion of the back barrier for extreme sea-level rise. Although it has the highest initial costs, a life cycle cost analysis for each strategy may reveal that periodic renourishment over several decades of sea-level rise could have greater costs than the initial cost of strategy D. Additionally, the analyses may reveal that it makes more sense to strategically relocate some of the infrastructure and aspects of the community.

Excerpt from Smallegan S. M., Irish, J. L., and van Dongeren, A. R. (2017) Developed barrier island adaptation strategies to hurricane forcing under rising sea levels. Climate Change.

(a)

Strategy (sediment volume added, m^3)	Beach raised by SLR	Dune raised by SLR	Seawall raised by			Back barrier raised to minimum elevation
			0.5 m	1.0 m	2.0 m	
EC						
A (8,32,71)	X					
B (11, 68, 145)	X	X				
C (11, 68, 145)	X	X	X	X	X	
C1.0 (10, 67, 144)	X	X	X	X	X	
C2.0 (7, 64, 141)	X	X	X	X	X	
D (13, 128, 322)	X	X				X
E (13, 128, 322)	X	X	X			X
E1.0 (12, 127, 321)	X	X		X		X
E2.0 (9, 124, 318)	X	X			X	X

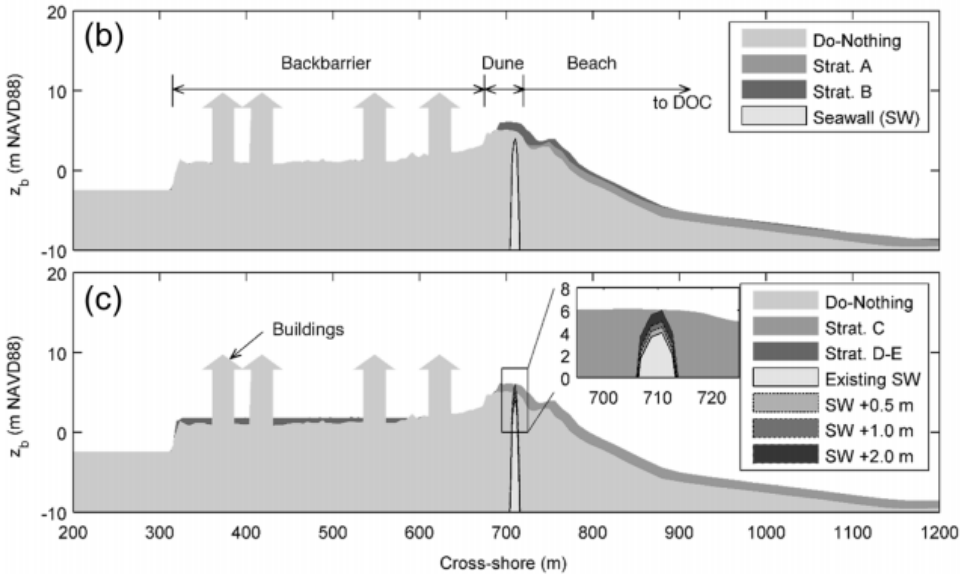


Fig. 2 Characteristics of adaptation strategies (**a**) and representative cross-shore profiles for SLR = +1.0 m: **b** EC elevation (z_b) and strategies A–B; **c** EC z_b and strategies C–E. Initial volumes are per unit width. Buildings are peaks in data and the seawall is represented by *shaded regions* at cross-shore distance 785 m. *SW* denotes seawall, and *DOC* is the depth of closure

Image: Figure 2 from Smallegan S. M., Irish, J. L., and van Dongeren, A. R. (2017) Developed barrier island adaptation strategies to hurricane forcing under rising sea levels title. *Climatic Change.*

Fig. 5 Policy pathway for Bay Head under SLR scenarios

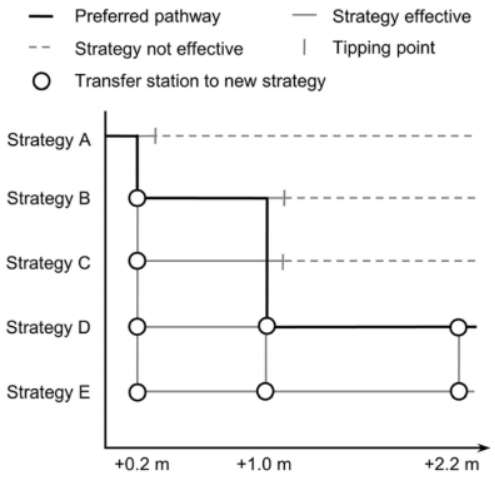


Image: Figure 5 from Smallegan S. M., Irish, J. L., and van Dongeren, A. R. (2017) Developed barrier island adaptation strategies to hurricane forcing under rising sea levels. *Climatic*

STUDENT PAGE | Sea-Level Rise Risk & Reward

DO NOW:

Describe how you currently think about sea-level rise in regards to living along the coast.

EXIT TICKET:

Why is having a mitigation plan that changes helpful for community resilience?

4.2 Stakeholder Roll Call

AGE RANGE
9th—12th grade

TIME REQUIRED
60 minutes

ACTIVITY OVERVIEW
Engage: Case Study Videos
Explore: Stakeholder Categories
Explain: Role Play Preparation
Elaborate: "Council Meeting"
Evaluate: Presentations

MATERIALS
Student Worksheet
Student Role Cards
Computers

BASED ON:
Resources from Planning and Facilitating Collaborative Meetings by NOAA Office for Coastal Management

LESSON TOPIC: Stakeholder participation

ACTIVITY SUMMARY: Students will role play as community stakeholders responding to local high tide flooding.

OBJECTIVES:

Students will be able to:

- Categorize types of stakeholders.
- Explore the benefits of including a wide range of stakeholders.
- Discuss solutions to high tide flooding.

LESSON BACKGROUND: A collaborative process (also referred to as collaborative decision making, facilitated processes, consensus building, participatory decision making, systematic problem solving, etc.) engages multiple stakeholders in cooperative deliberations in order to address issues and solve problems. The issues addressed may be internal to organizations or in the public arena. The collaborative process often improves the relationship of involved parties, encourages high quality input, and aids in the construction of mutually acceptable agreements. Public agencies use collaborative processes to build consensus and gain strong support for proposed solutions to public issues.

When collaborative processes are conducted properly, participants obtain a clear understanding of the issue and have analyzed all relevant facts together—before jointly developing solutions that represent the whole group's best thinking about the optimal decision. A consensus decision is reached when everyone says, "I can live with this decision, and I will support its implementation." A

collaborative process should be designed to get to this point—even if the consensus is that the group agrees to use one of the other decision-making methods to reach the final agreement.

While science can serve as a rational foundation for natural resource management or community planning, in many cases it is those groups impacted by the decisions that decide how acceptable a decision is and influence how effective the implementation will be. Peoples' experiences and culture, understanding of an issue, and support of an agency can shape their support for and compliance with coastal resource management decisions and policies.

Involving stakeholders in decision-making can accomplish the following:

- Produce better outcomes or decisions
- Garner public support for agencies and their decisions
- Bring to light important local knowledge
- Increase public understanding of natural resource issues or management decisions
- Reduce or resolve conflicts between stakeholders
- Ensure implementation of new programs or policies
- Increase compliance with natural resource laws and regulations
- Help agencies understand flaws in existing management strategies or potential unintended consequences from new decisions
- Create new relationships among stakeholders

Practitioners of stakeholder participation will jokingly define a stakeholder as "anybody who wants to be." There is much truth to this broad definition. Stakeholders are generally those who have an interest in or are affected by a decision. Stakeholders are also those who have influence or power in a situation. Stakeholders' interests in an issue can be monetary, professional, personal, or cultural, and can arise from a host of other motivations.

From the Planning and Facilitating Collaborative Meetings by NOAA Office for Coastal Management Training Manual

VOCABULARY:

Collaborative	A collaborative process (also referred to as collaborative decision making, facilitated processes, consensus building, participatory decision making, systematic problem solving, etc.) engages multiple stakeholders in cooperative deliberations in order to address issues and solve problems.

Community Planning	Public participatory process where future goals and objectives for the community are identified, priorities for project funding and implementation are set, and current policies are evaluated/revised.
Stakeholders	An individual or group that has an interest in any decision or activity of an organization.

ENGAGE:

Show the case study video to the class. This 5-minute video follows the city of Covington, Louisiana as they make a plan for preparing for flooding.

Alabama version: https://vimeo.com/322242513

Mississippi version: https://vimeo.com/322242202

Introduce the community issue for this lesson:
Azaleaville is located on the coast along the northern Gulf of Mexico. The north part of Azaleaville is unincorporated county and there are two neighboring cities to the east and to the west. In the early 19th century, a local seafood industry developed in Azaleaville. In 1838, the city constructed a lighthouse to guide fishermen safely home. Azaleaville's seafood market increased steadily throughout the 20th century, and the local fishing community survived dozens of hurricanes and tropical storms. More recently, however, the Deepwater Horizon Oil Spill in 2010 and the adverse environmental impacts of the opening of the Bonnet Carré spillway have severely reduced the seafood industry. On August 29th, 2005, Hurricane Katrina hit the coast near Azaleaville as a category 3 storm and caused a record high storm surge of 27.8 feet (8.47 meters) with sustained winds of 120 mph. Storm damage from Katrina left many empty lots and vacant businesses. Azaleaville has been slow to rebuild in part because of the cost required to comply with building codes for buildings to be above base flood elevation and due to the high cost of flood insurance. Although rain, wind, and storm surge from tropical storms and hurricanes pose the most severe flooding threats, riverine and flash flooding from local and upriver thunderstorms have recently increased in Azaleaville. There is a 47% chance that Azaleaville will experience a flash, coastal, or riverine (non-hurricane) flood in any given year, and flooding can occur anytime during the year.

Sea-level rise is leading to more days of high tide flooding in Azaleaville. The main road leading to the high school is blocked by flood water often during the year but especially in September, October, and November. This flooding is already happening now, and with future sea-level rise projections the number of flooding days will increase. This flooding is preventing buses and cars from entering the school drop off area and the parking lot for students who drive to school is reduced by half. A Community Meeting was called to convene with a diverse group of stakeholders, who serve and/or represent different community sectors in Azaleaville.

EXPLORE:

In this lesson, students will take on roles of specific community members to address a community issue. Before they can begin their "Community Meeting" they must identify the stakeholders (the people involved with the issue). Students read the excerpt from Stakeholder Participation from NOAA's Office for Coastal Management as the Student Reading.

Using the Student Worksheet chart, students can work individually or in pairs to generate a list of stakeholders who are impacted by the Azaleaville high-tide flooding blocking access to the high school.

EXPLAIN:

Divide students into groups of 5-6. Students will be given a role to play for the Community Meeting of how the community will address the high-tide flooding at the high school. Students should take a few minutes to think about the person they will be playing and how that person would handle the high-tide flooding at the high school. **Alternative:** Use the activity as a whole class exercise instead of separating into individual groups. Multiple students would then be in each stakeholder group and would be encouraged to speak up.

> **EXTENSION:** Students can be assigned their role ahead of time and be required to research that role by speaking to individuals in that role in their community. You can also have the students think of this activity as a drama/play and they can dress up for their role.

The specific Community Meeting goals are to better understand:

- The risks and impacts of floods on the community
- Actions the community is taking now and could take in the future to mitigate future floods
- Challenges the community continues to face related to flood mitigation
- What the community needs to enable them to make informed decisions about flood mitigation
- How the community is funding their flood mitigation activity

Note: These cards at the end of the section are formatted to be printed on Avery5390 Name Badge Inserts (2-1/4" x 3-1/2").

First Responder

- Your career is devoted to keeping others safe.
- You respond first to emergencies making sure to enforce the law and provide medical help.
- You are aware that the flooding by the high school might lead to students walking across busy roads with more chance of accidents.

Local Government Official

- You are committed to your region and work to serve the best interests of both residents and businesses.
- You have a good working relationship with other levels of government and your city's first responders.
- You understand that a strong school system draws parents to move to your town and increases tax revenue and your ability to provide critical services to the town.

Principal

- You are the principal of the high school.
- The principal is responsible if anything happens to the students while on school property.
- You want to ensure easy access to the school for students and you promote a well-rounded education.

Teacher

- You work as a teacher at the high school and you have a strong community network.
- You live nearby the school and walk to work along the road that is often flooded.

Local Resident - Fisherman

- You are a working professional with no children, you work at the fishing docks and live across town from the high school.
- You are worried huge construction projects to flood proof the city will impact your day to day life or could cause flooding in new places that will negatively impact you.

Local Resident - Parent

- You are a parent with two children in the high school, and you work near the school and drop your kids off on your way to work.
- You are concerned about the safety of dropping your children off at school on the busy road.

High School Student

- You are a student at the high school and drive yourself to school.
- You are concerned about driving through the flooded road and about the lack of parking.

ELABORATE:

In their groups, students will play their role and discuss at the Community Meeting their thoughts for mitigating the high-tide flooding by the high school. They should be presenting their thoughts for mitigating the flooding impacts while also persuading other members to support their idea.

Review the following class discussion norms to ensure a successful Community Meeting:

- Allow everyone a chance to speak
- Actively listen

- Listen respectively
- Constructively critique ideas, not individuals
- Be open to changing your perspectives based on what you learn from others

Guide the discussion with the following questions:

- How does flooding impact your community?
- What are the main flood risks in your community?
- What actions has your community already taken to mitigate floods?
- What are your plans for future mitigation actions?
- What are examples of how your community coordinates flood mitigation efforts across the public, private, and/or nonprofit sectors or across jurisdictions?
- How can your community fund your flood mitigation activities?
- What are the main barriers or challenges that obstruct your ability to take action to mitigate against floods?
- How complex is the solution?
- Is there an opportunity for public engagement?

At the end of the time have them decide on the "winning" solution or combination of solutions. The "winning" solution or combination of solutions is agreed upon by the group. Note to the class there is also a cost to doing nothing. There can also be litigation against the school district to contend with regardless of the action taken so the city and/or school district attorney will likely be involved.

Note to teachers: allow the students to come up with the ideas for solutions on their own. All ideas are encouraged. As a group facilitator you can provide options as necessary. These may include:

- Road elevation or pedestrian path elevation
- Additional rain gardens or water absorbing areas
- Improvements to the storm water drains or updating old infrastructure
- Road detours leading to the high school
- Elevating the high school
- High school relocation
- Adjusting the start dates of school, i.e. school break or virtual over the heavy flooding

EVALUATE:

Bring all the students back together to present the winning solution from each group.

Extension: ask students what **their** decision would have been and how does that compare with the role they played.

FIRST RESPONDER

- Your career is devoted to keeping others safe.
- You respond first to emergencies, making sure to enforce the law and provide medical help.
- You are aware that the flooding by the high school might lead to students walking across busy roads with more chance of accidents.

PRINCIPAL

- You are the principal of the high school.
- The principal is responsible if anything happens to the students while on school property.
- You want to ensure easy access to the school for students and you promote a well-rounded education.

LOCAL GOVERNMENT OFFICIAL

- You are committed to your region and work to serve the best interests of both residents and businesses.
- You have a good working relationship with other levels of government and your city's first responders.
- You understand that a strong school system draws parents to move to your town and increases tax revenue and your ability to provide critical services to the town.

TEACHER

- You work as a teacher at the high school and you have a strong community network.
- You live nearby the school and walk to work along the road the is often flooded.

LOCAL RESIDENT - FISHERMAN

- You are a working professional with no children, you work at the fishing docks and live across town from the high school.
- You are worried huge construction projects to flood proof the city will impact your day to day life.

LOCAL RESIDENT - PARENT

- You are a parent with two children in the high school, and you work near the school and drop your kids off on your way to work.
- You are concerned about the safety of dropping your children off at school on the busy road.

HIGH SCHOOL STUDENT

- You are a student at the high school and drive yourself to school.
- You are concerned about driving through the flooded road and about the lack of parking.

STUDENT PAGE | Stakeholder Roll Call

In the following chart, generate a list of stakeholders who are impacted by the Azaleaville high-tide flooding blocking access to the high school.

Stakeholder Category	Stakeholder – name of group or individual
Those who are directly affected	
Those with decision-making authority	
Those who have resources or skills that may be needed	
Those who will be implementing the results or outcomes	
Those who will actively oppose the process	
Those who will actively support the process	

STUDENT PAGE | Stakeholder Roll Call

Azaleaville high-tide flooding brainstorm:

What is your role in the community: _____

How are you impacted by the high-tide flooding at the school?

What do you propose that your community do to address the high-tide flooding? (Use the space below to brainstorm a few different options).

Draft your proposal to the community:

a) State how this high-tide flooding is impacting your role:

b) State your suggestion for addressing the issue:

c) Explain why your suggestion is the most effective for your community:

Stakeholder Participation

"The public's attitudes, perceptions, beliefs, and knowledge can have a profound effect on the success of coastal resource management. While science can serve as a rational foundation for management, in many cases it is those groups impacted by resource management decisions that decide how acceptable a decision is and influence how effective management will be. Peoples' experiences and culture, understanding of an issue, and support of an agency can each shape their support for and compliance with coastal resource management decisions and policies. Over the past several decades, traditional top-down, agency-driven decision-making in natural resource management has generally moved toward processes that involve stakeholders (those who have an interest in or are affected by a decision) and acknowledge the importance of public attitudes, perceptions, beliefs, and knowledge. Specifically, involving stakeholders in natural resource management decisions can accomplish the following:

- Produce better outcomes or decisions
- Garner public support for agencies and their decisions
- Bring to light important local knowledge about natural resources
- Increase public understanding of natural resource issues or management decisions
- Reduce or resolve conflicts between stakeholders
- Ensure implementation of new programs or policies
- Increase compliance with natural resource laws and regulations
- Help agencies understand flaws in existing management strategies
- Create new relationships among stakeholders

Of course, stakeholder participation can also pose challenges. Involving stakeholders can be costly, time consuming, labor-intensive, and confrontational - and can ultimately delay decision-making. Additionally, if improperly managed, stakeholder participation can create new conflicts or escalate existing ones."

Excerpt from "Resources from Planning and Facilitating Collaborative Meetings" by NOAA Office for Coastal Management.

STUDENT PAGE | Stakeholder Roll Call

DO NOW:

What is high-tide flooding?

EXIT TICKET:

Why is it important to bring all members of the community together to discuss flooding and sea-level rise resilience? "In your opinion, which stakeholder presented the best argument and why?"

4.3 Kingtown – Planning with a Purpose

AGE RANGE

9th—12th grade

TIME REQUIRED

80 minutes

ACTIVITY OVERVIEW

Engage: Kingtown Introduction
Explore: Stakeholders
Explain: Discussion
Elaborate: Resilience Planning
Evaluate: Impact Discussion

MATERIALS

Student Worksheet
Computers

BASED ON:

This lesson is used with permission from Museum of Science Boston, NOAA, Arizona State University, and Northeastern University.

LESSON TOPIC: Community planning for sea-level rise resilience.

ACTIVITY SUMMARY: Students will explore Kingtown and different sea-level rise resilience plans.

OBJECTIVES:

Students will be able to:

- Explore resilience plan strategies for a city impacted by sea-level rise.
- View results and impacts of different sea-level rise resilience strategies.

LESSON BACKGROUND: The Climate Hazard Resilience Forum was developed in partnership with Arizona State University and Northeastern University and supported by a NOAA Environmental Literacy Grant. This deliberative forum brings the participants through the resilience planning process for various generic cities in specific contexts. Each city is based on a real place and uses real data but was anonymized for unbiased deliberation. Participants learn and discuss stakeholder values, consider trade-offs of various resilience strategies, make a final resilience plan, and then experience visualizations of how their plan will affect the city and the people who live there. The fictional towns are visualized through online ArcGIS StoryMaps created by Northeastern University. To learn how to use StoryMaps for this forum, access the training video through this link: https://www.youtube.com/watch?v=55e2tiLpvcs&feature=youtu.be.

Kingtown is a fictional town used to demonstrate sea-level rise resilience. In Kingtown, sea levels have risen by about a foot over the last century. Some high-tide flooding occurs, even when there are no precipitation or strong wind events. These floods may be only a foot or two deep, but can

cause roadways to be impassable, flood basements in low-lying areas with saltwater, or negatively impact coastal ecosystems.

Kingtown is now prone to flooding on the streets at high tides and during coastal storms. This matters because the structures we build to protect ourselves are built for the sea level people experienced a century or more ago. When we have high tide and waves from storms on top of sea-level rise, water washes onshore. This means Kingtown is at increased risk to flood impacts and needs to become more resilient.

Students will use visualizations to explore potential vulnerabilities to city infrastructures, social networks, and ecosystems from sea level rise, then discuss potential strategies for addressing the threat, focusing on the priorities and needs of relevant stakeholders. Students will then make recommendations for increasing their city's community resilience.

VOCABULARY:

Conservation Planning	Specific to maintain natural values and assets in a specific landscape or seascape with competing uses, values, and other threats and opportunities.
Equity	The fair and just practices and policies that ensure all community members can thrive. Equity is different than equality in that equality implies treating everyone as if their experiences are exactly the same.
Historic Preservation	Utilizing planning to protect historic sites and resources (e.g., monuments, buildings) from hazards related to climate change (e.g., acid rain, increased erosion, extreme weather).
Land Use	Management of land, including the social and economic potential that the land use provides (e.g., grazing, timber, and conservation).
Managed Retreat	The purposeful, coordinated movement of people and buildings away from risks. At the same time, natural coastal habitat is enhanced seaward of a new line of defense. Also referred to as strategic relocation or managed realignment.

ENGAGE:

In this lesson, students will be able to work in groups to determine a resilience strategy for the town of Kingtown. The town and all information is available on the website: https://arcg.is/15rSzD . Through this web portal, students will be able to see the effects of their chosen resilience plan.

Start the lesson by showing the students Kingtown on the "Kingtown" tab. Scroll through the infrastructure and the last image of sea-level rise impacts on the city.

EXPLORE:

Assign students one of the stakeholders from the "Stakeholders" tab: Emergency Room Doctor, Local Resident, Oyster Farmer, Power Plant CEO, Transit Worker, and Economic Development Director. They have 5 minutes to read over the different perspectives.

Students will then discuss in their groups the different stakeholder perspectives, and the demographics of the city on the "Demographics" Tab. There are three strategies for dealing with the impacts of sea-level rise in Kingtown: Keep Water Out, Living with Water, and Managed Retreat. Each strategy has a Plan A (larger and more expensive) and a Plan B (smaller scale and less expensive). Students can explore these options by clicking through the named tabs. As a group, they will prioritize the values of what to protect from sea-level rise impacts and how they will do it with their limited resources. (15 minutes)

EXPLAIN:

Come together as a class to share which resilience plan each group chose. Look at the results of one resilience plan option. There are 17 possible outcomes so choose one not picked by any of the groups. The tab "Submit Resilience Plan" shows the images of each plan option on the left side, and when those are clicked you are brought to a new story map that reflects changes to the community based on the plan. Walk through all the impacts with the group on the new story map (10 minutes)

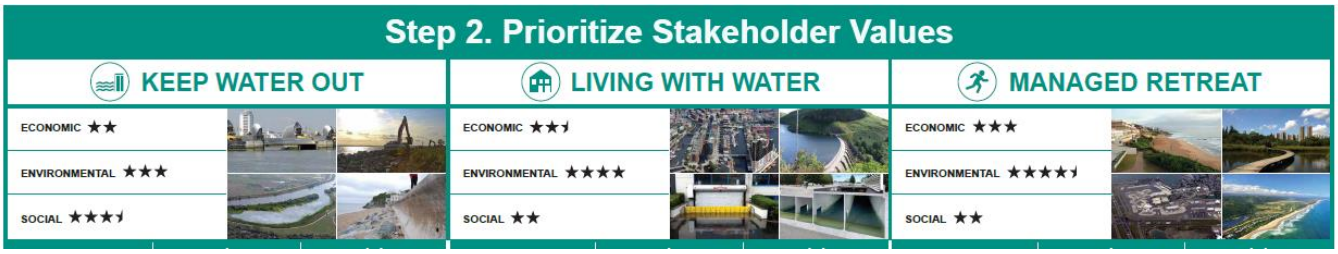
ELABORATE:

Groups go back to working together to explore the impacts from their chosen resilience plan. (20 minutes)

EVALUATE:

Groups share the resilience plan they chose as well as the impacts to Kingtown based on their decision. Ask them to reflect on what the ramifications of these impacts might mean for the residents living in the town. The new maps for each resilience plan has information describing the changes, and students can summarize this information to present to the class. Students can also be asked to compare their personal decision to that of their assigned stakeholder. (10 minutes)

As a group prioritize the values: Economic, Environmental, and Social. Next to each strategy in the chart below is a star ranking of how the strategy will impact Economic, Environmental, and Social values. Decide which value is the most important to you to protect.



Your group is allotted 3 coins for your resilience plan selection.

Plan A costs 2 coins and Plan B costs 1 coin. You cannot spend all three coins on one strategy, and you do not have to spend all three. **Decide as a group which resilience plan you choose on the following page.**

My Resilience Plan 1

KEEP WATER OUT 	LIVING WITH WATER 	MANAGED RETREAT 
Plan A	Plan A	Plan A
		
Plan B	Plan B	Plan B
		

What resilience plan would you make for Kingtown? Why did you choose this plan?

Mark the empty coin spaces to choose a plan. Remember you only have three coins and can't use all three on one strategy!

STUDENT PAGE | Kingtown – Planning with a Purpose

DO NOW:

Suggest a method for a community to equitably discuss the possibility of managed retreat in a Community Meeting.

EXIT TICKET:

Which value below is most important to you? Explain.

- Keep Water Out
  - Economic – 2 stars
  - Environmental – 3 stars
  - Social – 3.5 stars
- Living with Water
  - Economic – 2.5 stars
  - Environmental – 4 stars
  - Social – 2 stars
- Managed Retreat
  - Economic – 3 stars
  - Environmental – 4.5 stars
  - Social – 2 stars