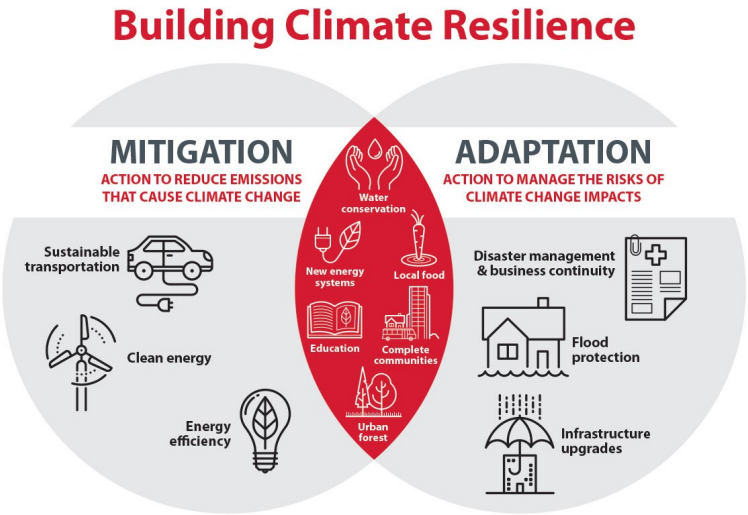
ADAPTATION & RESILIENCY

Unit V: How can humans adapt to climate change in an equitable way?

Our planet is already experiencing the impacts of accelerated climate change, and will continue to for some time even after we begin our best mitigation efforts. Though we may each experience climate change differently, every person, community, state, and country must assess local risks and vulnerabilities and adapt to projected impacts. We live in an interdependent world, however, so it serves our own best interests to help protect the infrastructure and resources of other populations around the globe as well. There is also a moral imperative to do so. Often the populations that are *least* responsible for our current level of heat-trapping greenhouse gases are the ones most affected. Small, island nations are being swallowed up by rising seas, impoverished populations are seeing their homes and farms devastated by more powerful storms, indigenous peoples are losing access to traditional foods and homelands due to habitat loss and species range changes, and the very young, elderly, and sick are most vulnerable to resulting air pollution and heatwaves.

In this unit, we will examine myriad adaptation responses to the types of climate change impacts described in Unit III. Sometimes, adaptation planning can coincide with carbon mitigation efforts, as it does when we plant more trees. Where mitigation and adaptation meet can be called resilience. **Resilience** is defined as the ability to withstand or bounce back from challenging conditions or disturbances to our natural and built environment. The ultimate goal is to build a more resilient and sustainable world. Urban spaces may have to respond to challenges that are dissimilar to rural environments and will have to react accordingly, just as the marine organisms will adapt differently to climate change than land-dwellers.



Source: Official website of the City of Calgary, Alberta, Canada

While some strategies can be developed and adopted across the globe, others will need tailoring to hyper-local circumstances. For instance, Yonkers has a built waterfront along the tidal estuary portion of the Hudson River. Rising sea-levels combined with storm surge events, like Hurricane Sandy, make the developing waterfront vulnerable to coastal flooding, while heavy rain events cause frequent flooding on the highways and erosion along the smaller Saw Mill and Bronx Rivers. To address these and projected issues, Groundwork Hudson Valley has worked with partners such as the New York Department of Environmental Conservation and the City of Yonkers to (1) plant native willows

Unit V: Adaptation and Resilience—continued

along the Saw Mill River while removing invasive species to stabilize the shoreline and alleviate flooding on roadways; (2) develop a "Greenway" path along an abandoned train line to promote more biking and walking, thus reducing traffic and vehicle emissions; (3) promote local agricultural production through the Science Barge hydroponic farm and community gardens; and (4) reduce or eliminate combined sewage overflow from flooding/surge events by "daylighting" buried portions of Saw Mill River, diverting excess storm water into the old culverts, and installing **bioswales** in the adjacent parks. There is still more work to be done, but it is a good start.



Source: Groundwork Hudson Valley

Generally, our most vital areas of focus are: infrastructure, coasts, food systems, emergency preparedness and crisis response, local energy backups, water and natural resource management, and public health. Woven through all of these is the need for information. Only through research, reporting, and public education can communities gain true resilience. Climate education can save lives, too. The more knowledgeable citizens are about their individual risks, the better they can prepare and respond during disasters. Local and federal governments can also use data to predict,

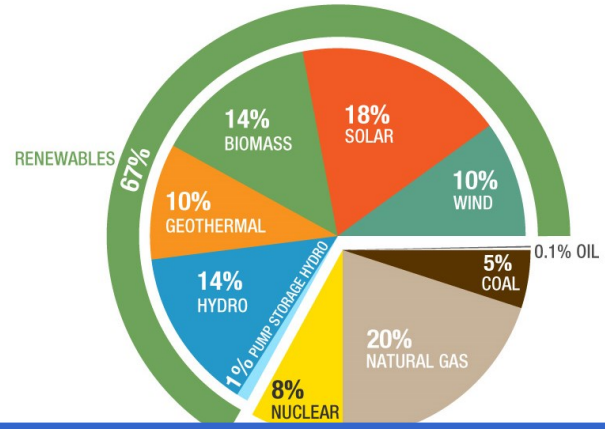
> "Statistics on the occurrence of these extreme events and the people and infrastructure at risk are essential for disaster risk management and saving lives. When an extreme event results in a significant disruption of the functioning of society we call it a disaster. What kind of information is vital to save lives when a disaster strikes?
>
> At first glance, the first questions that come to mind are: How many people are affected? How many are at risk? How many impaired or elderly live there? What relief means are available or can be rapidly mobilized? Immediate action is required and being efficient relies on accurate, up-to-date, ready-to-be-used information.
>
> After facing the first impact, new challenges need to be evaluated: Will the food, water and electricity production and supply be affected? How many houses or roads need to be reconstructed? What are the social and economic impacts?" —UN Economic Commission for Europe

prepare for, and respond to climate change related hazards more efficiently.

The National Oceanic and Atmospheric Administration (NOAA) is committed to not only gathering useful climate change and impact data, but also disseminating it to create a more resilient public. They have compiled a list of information and education resources (some by NOAA and others external) to better inform communities at all levels. You can find it here: https://www.noaa.gov/office-education/elp/resilience-assets.

V.A: Global: Energy, Food, and Water

Shift to renewable energy by 2050 as proposed by the Institute for Sustainable Energy Policies



Key Concepts and Web-app Resources:

Resilience for the future of humanity hinges on the management of energy, food, and water. We learned in **UNIT III: Climate Change Impact** how each would be affected as the planet continues to warm in the coming decades. Practice budgeting for these key resources while accounting for fringe expenses or increased demand after disasters like heat, drought, and flood-contamination will help us meet our needs and save resources for a more sustainable future. Cutting out fossil fuel production tomorrow is not an option, given increasing energy demand around the world, as well as oil's use in plastic production and coal's role in steel production. However, if we budget for immediate-but-gradual shifts to clean energy technology, while improving efficiency and conservation efforts, we can meet or surpass our carbon mitigation commitments to the Paris Agreement worldwide. By using the web-app resources listed below, especially the **Meeting World Energy Lab** (also found here: http://www.learner.org/courses/envsci/interactives/energy/energy.html)**, Climate Smart Agriculture** video (also found here: https://youtu.be/lUdNMsVDIZ0), and **Be Water Wise** images (right click to save or print), you can foster meaningful dialogue with students about practical solutions.

"We have to understand the ubiquity of energy in everything we do. Energy is core to our economy and it brings with it environmental challenges, and it's core to our security challenges."

- Ernest Moniz, former secretary of the US Department of Energy

Unit VA. Web-app Resources:

>Adaptation and Resiliency

>>The Global Effort

>>>Benefits of Global Action (EPA Video)

>>>Climate Smart Agriculture

>>>Breeding Resilience Into our Forests (American Chestnut Foundation)

>>>Meeting World Energy Lab (by The Habitable Planet)

>>>Our Future Starts NOW (UN Markers on Sustainable Development)

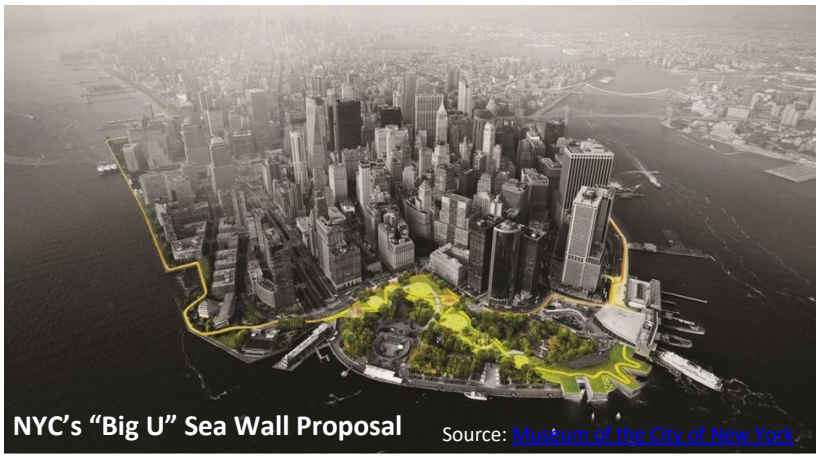
>>Think Globally, Act Locally

>>>Be Water Wise

V.B: Coastal Communities: Rising Above the Tide

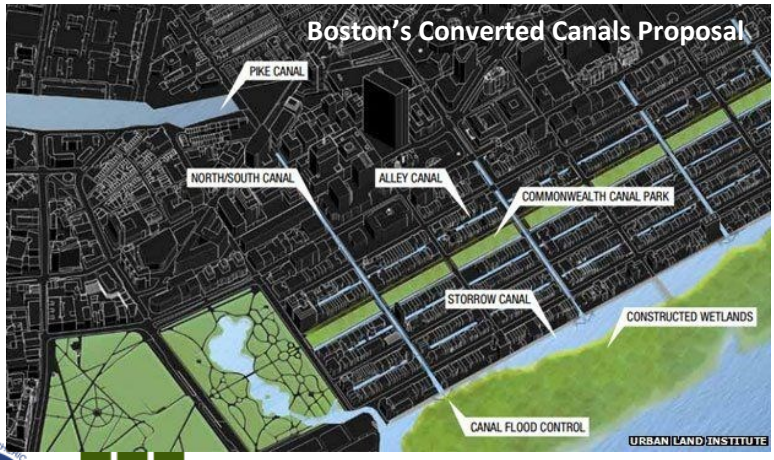
Key Concepts and Web-app Resources:

The coastlines of our oceans and rivers have connected us since the very beginnings of civilization. Floodplains around rivers contained fertile soils and rafting heavy building stones and logs for buildings, forts, and monuments did not require advanced technology. The oceans and estuaries provided an abundant food source. As settlements sprung up around the world, our waterways served as the backbone for trade routes and emigration. Today, over 40% of the world's population live within 60 miles from the ocean, according to the UN, and 75% of "**megacities**" like Singapore, Tokyo, Delhi, Lagos, New York, and Los Angeles are located on a coastline. Furthermore, those percentages are still increasing. NOAA reported that by 2020, roughly *half* of Americans will be living along the coasts. Coastlines have always been dynamic environments, offering as many challenges as they do benefits. The rising tides of climate change only serve to exacerbate this. The primary concerns are storm surge, erosion, saltwater encroachment [of freshwater aquifers], and degrading fisheries, but cities with little elevation gain above sea level are at even greater and more immediate risk.



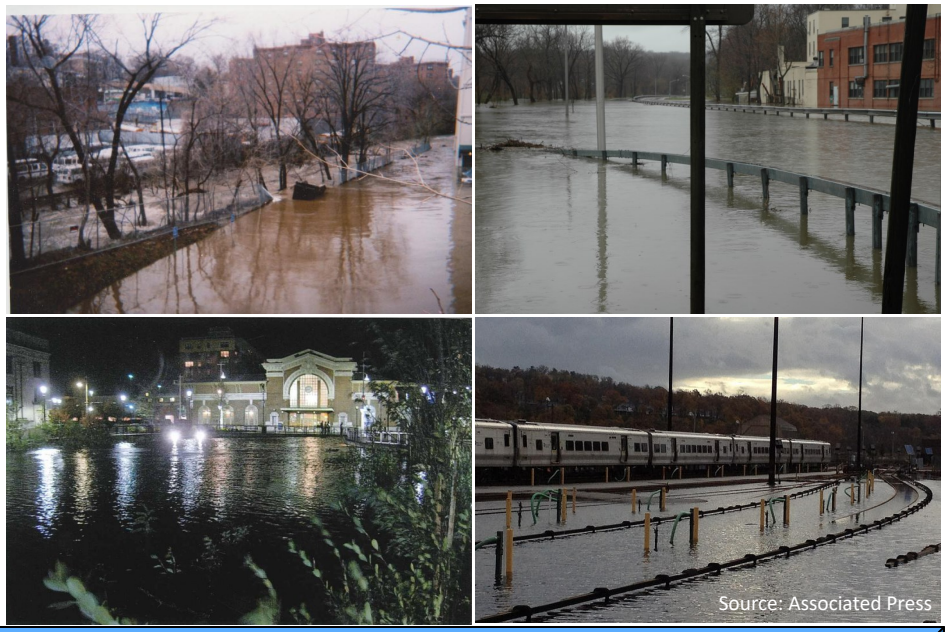
NYC's "Big U" Sea Wall Proposal Source: Museum of the City of New York

The densely populated coastal cities of Miami, Boston, and New York City are racing against time to strategize how best to confront both the imminent and future impacts of rising sea levels and more powerful storms. From water pumps to sea walls, adaptation plans vary depending on the needs and financial resources of each municipality. Often projects that combine efforts to restore and enhance natural buffers while also building new barriers and levees is deemed the best approach—provided public will, capital, and other necessary resources exist to support it! In Miami, where sunny-day flooding during high tide has become an increasingly common phenomenon, mangroves, reefs and wetlands are getting new protections, while engineers work on raising roads, utilities, and installing new pumps to return rising tidewater back to the bay. For New York City—devastated by $19 billion dollars worth of damages by 2012's Hurricane Sandy— $335 million dollars has been allocated to develop plans for a barrier wall and park space to stem future flooding in the "big U" of lower Manhattan. The project, if completed, will cost over $1 billion dollars. In Boston, the city was built on a marsh at the mouth of the Charles River and is therefore *doubly* vulnerable to flooding from increased precipitation *and* sea level rise. One of their most recent proposals to confront the issue is to accommodate rising waters by converting low-lying roads into canals, essentially turning Boston into the "Venice of New England."



V.B: Coastal Communities: Rising Above the Tide page 2/2

In Yonkers, New York, there are *storm surge* risks from the Hudson River Estuary as well as *stormwater overflow* risks from the Saw Mill and Bronx Rivers. During Hurricane Sandy, the Yonkers' waterfront was flooded by a six foot surge, including the Metro North train station that brings thousands of commuters into the city, the public library, a school bus depot, riverside apartment buildings, some manufacturing plants, and the wastewater treatment plant. The damages to the wastewater system alone topped $14 million. The small portion of the waterfront adjacent to the wastewater plant was buffered by a natural tidal marsh ecosystem. The Center for the Urban River at Beczak (CURB) building was not flooded because the greenspace around it acted like a sponge, absorbing the rising Hudson. Future projections of sea level will raise the baseline height of the Hudson tidal estuary to the Hurricane Sandy storm surge level—6 ft higher by the year 2100. Raising sea walls in the Yonkers' waterfront may not be sufficient for future storm events. More wetland areas like the marsh by CURB may be warranted, with added benefits to the river's water quality and its fisheries.



Top left of page: Yonkers Water Treatment Plant (Associated Press)
Right, going clockwise: Flooding by the Bronx River (); flooded highways bordering the Saw Mill River (), along the Metro North Hudson line south of Yonkers (Associated Press), and at Yonkers Station where the Saw Mill meets the Hudson river (Donna Davis)

Unit 1A. Web-app Resources:

>Adaptation and Resilience

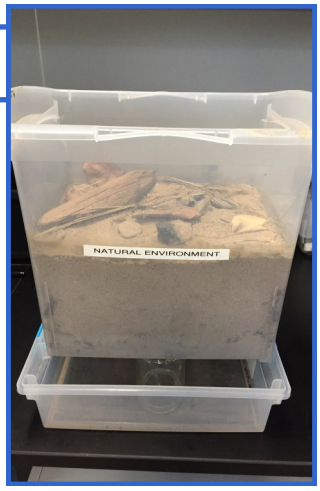
>>Coastal Resilience

>>>**Estuary Model & Coastal Resilience** (SLC CURB Video)

>>>**Coastal Resilience** (The Nature Conservancy Video)

>>>**NOAA Digital Coast Mapping Tool**

V.B: Coastal Communities— Storm Surge



Lesson: How will climate change affect the built environments on our coasts?

Subject / grade level: 9-12th grade, Environmental science

Materials:

- Internet access and computers for the online mappers
- For marsh/built environment demo:
  - Two plastic bins with holes drilled into the bottom to let water out, two more bins to let water drip into, wooden blocks or wide jars to hold up the models
    - For marsh environment: collect sand, rocks, dried grasses, seashells, etc. and pile up into bin
    - For built environment: collect larger rocks, Lego or other houses, toy cars, etc.

NGSS Standards

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.
ESS2.D: Weather and Climate
ESS3.C: Human Impacts on Earth Systems
ESS3.D: Global Climate Change

Lesson objective(s): Students will understand how climate change impacts their coastal surroundings, and evaluate ideas for combating these detrimental effects using physical investigation and mapping models.

ENGAGEMENT

- Ask students if they remember any major recent storms (Superstorm Sandy, Hurricane Irene, the blizzard on Halloween, Hurricanes in Texas, Florida, or Puerto Rico from 2017). What effect did these storms have on their houses or communities? Did they lose power? Could they go trick-or-treating? Were their family members in other states or cities affected? Did their houses or cars get damaged?
- What impact will a changing climate have on storm intensity and frequency?
- What other impact will climate change have on our oceans and coastal areas around the world?

EXPLORATION

Why was Superstorm Sandy so devastating to the coastal community? There wasn't actually that much rain, yet flooding was a huge issue throughout the lower Hudson. What is storm surge?

Web-app Resources:
Climate Change Impacts
>Oceans and Coasts>
Storm Surge Video

- Storm surges tear up shorelines, redistribute sand, and remove sediment and mud from the local ecosystem.
- Strong winds drive storm surges and crashing waves into land, damaging habitats.
- Floods alter salinity levels, cause higher tides, and redistribute organisms.
- Erosion of shorelines and sediment displacement due to wave action and stronger currents.

V.B: Coastal Communities— Storm Surge (page 2)

EXPLANATION

- How far does storm surge (and sea level rise) actually travel up the coast? What does a 6 foot storm surge actually mean? (6 feet is also the worst-case scenario prediction for sea level rise in Yonkers by the year 2100)
- If you have access to a coastal park or beach (must be a soft shoreline, not a pier or bulkhead), teachers can take students to explore the area and find out just how far the water would move up the land in their community with this extension lesson/activity: http://www.seagrant.sunysb.edu/hriver/pdfs/climatechange/HRCC_Lesson9.pdf
- If no coastal access, have students explore on the Internet. In the Hudson Valley, use this website: http://www.scenichudson.org/slr/mapper
    - If anywhere else in the country, use NOAA's website: https://coast.noaa.gov/digitalcoast/tools/slr.html
- Students can increase the amount of sea level rise and watch how it will increase flooding in their local community.
- Have students fill out worksheet attached at the end of this lesson plan.

ELABORATION

Ask students what we can do to prevent the devastating impact of sea level rise and storm surge from more frequent extreme weather. If we can't stem the tide of climate change, what might we be able to do on our coasts?

Web-app Resources:

>Adaptation and Resiliency
>>Coastal Resilience
>>>**E**stuary Model & Coastal Resilience (SLC CURB Video)

>Adaptation and Resiliency
>>Coastal Resilience
>>>NOAA Digital Coast Mapping Tool

- If they don't offer, introduce marshes and wetlands:
    - Vital role in regulating water quality and chemistry
    - Removing pollutants
    - Sequestering carbon
    - Oxygenating the water
    - Storm surge buffers and flood control
    - Dissipating wave energy
    - Increasing the resilience of the uplands and waterfront communities

- Either set up built environment/wetland environment models beforehand, or have students create their own as an extension activity. Ask students which they think will absorb more water, and if/how that would help their local environment.
    - Have students pour water through their models and evaluate the results on worksheet.
- Now, have students explore real-world wetland models to see how they will be affected by sea level rise in the Hudson Valley: https://scenichudson.maps.arcgis.com/apps/MapSeries/index.html?appid=9190b7560a574ad69cd91b43e383b203

V.C: Local—Emergency Preparedness

Key Concepts and Web-app Resources:

According to the Red Cross, the frequency of reported weather-related disasters has doubled in the past two decades. Though proactive national and city adaptation strategies can broadly safeguard citizens from flooding, wildfire, heat waves, intense storms, and other natural disasters, they cannot usually protect *every* household. When disaster strikes, *individual readiness* is the only way to ensure your personal protection. Disaster preparedness includes the activities and measures taken in advance to effectively respond to the impact of hazards, such as the construction of early warning systems or building a 72-hour emergency kit. This can also include the planning of a possible evacuation of people and property from threatened locations. Individual readiness means being educated about risks, having provisions and a plan, and acting accordingly to the severity and locality of the threat.

NOAA's "Weather Ready Nation" is a national program that includes brochures, videos, checklists, and other information about weather-related impacts to stay informed and up-to-date on preparedness measures.

Unit VC. Web-app Resources:

>Adaptation and Resiliency

>>Think Globally, Act Locally

>>>Emergency Preparedness

>>>Weather Ready Nation (NOAA Videos)

>>>Simulated Hurricane Video

>>>Make and Emergency Plan & Kit (FEMA video)

>>>Designing Cities for Resilience

>>>The EcoHouse example (Groundwork Hudson Valley video)

>>>NOAA Resilience Toolkit: Climate Explorer

V.C: Local Emergency Preparedness—Classroom Activity

Lesson: Individual Readiness for Weather-Related Emergencies

Subject / grade level: 6th-9th grade, all subjects

Materials: Computer lab & Web-app OR Choose your own adventure Book download & Prep tokens; 72-hour Emergency Prep Kit; Checklist and Evacuation Plan worksheets

Source: FEMA

Lesson objective(s): Students will be able to identify and state the local extreme weather risks (e.g.: flash flood, hurricane or high winds, and heat waves) and individual/home vulnerabilities to address. Students will know what items should be included in every 72-hour emergency prep kit and have a contact list and evacuation plan.

ENGAGEMENT (Discussion based—10 minutes)

- Ask students if they can share an experience they have had in their lives with extreme weather. If they were personally affected, how? Did they ever *feel* in danger? Did they know how to respond if things became critical?
- How would they define "emergency preparedness?" What information is necessary to be prepared in their community? How/where would you obtain that information?
- How does climate change the likelihood of extreme weather events? Which extreme weather events do they think their community or home is most vulnerable to?

EXPLORATION (20 minutes)

- Using the Web-app, navigate to the NOAA Climate Explorer:
  >Adaptation and Resiliency>>Think Globally, Act Locally>>>NOAA Resiliece Toolkit: Climate Explorer
  (also found here: https://crt-climate-explorer.nemac.org/)
  - Note: Teacher's should have some experience with this site ahead of the class as familiarity with the tools will ease their use in the classroom.
  - Enter in your zip code at the top to generate temperature and precipitation data and maps closest to your hometown.
  - Starting with **temperature**, look at the risk of extreme heat and heat waves. First, open **"Average Daily Max Temperatures (°F),"** and select "**Monthly**." Use the red button below the chart to select the "**30-Years Centered in 2050.**" You can choose either a lower or higher emission scenario.
    - How does the average temperatures for July change for your hometown in the future? What might this mean for your hometown's vulnerability to extreme heat events?
    - You can also map this out by clicking "**Maps"** on the right. The curtain tool allows you to toggle between historical data and whichever decade you select on the time slider at the bottom.
    - Optional: Next, choose the "**Days with Max > 90°F**" option and compare the current number with the year 2020, 2030, 2040…
    - Ask students, how do they cope with summer heat waves? How might an increase in days with extreme heat impact their hobbies, vacation plans, homes cooling costs, etc.?

V.C: Local Emergency Preparedness—Classroom Activity (page 2/3)

- Next, scroll down to **Precipitation**, look at the risk of heavy rain events. First, open **"Days with > 1 in."** Use the blue buttons on the year-slider below to shrink the chart to the years 1985-2065 for better visibility. Be sure to chart **historical** information.

- How has the number of heavy rain events changed in your area over the past few decades, if at all? (Remember, every location could be different). If they have increased, what does this mean for potential flash flood events? Do the same for "**Days with >3 in**." This represents deluge conditions that are typically uncommon.
- Select the Mapping tool and move the curtain slider back and forth from past records to future projections. Shifts in color represent an increase (or decrease) of heavy rain events as it is mapped out over your city and region.
  - Climate change means that the warmer atmosphere can hold more water. As storm systems cool moving over the land, especially hills and mountains, the potential for much heavier downpours could increase in some areas, whereas neighboring cities may experience drought. An increased likelihood from year to year could spell hazardous road conditions, infrastructure damage, and property loss.
- Finally, in addition to heat waves or flash floods, ask students to identify any other region-specific risks, such as forest fires, hurricanes, tornadoes, heavy snow, etc.

EXPLANATION (20-40 minutes depending on number of modules covered).

- Using the Web-app, navigate to the NOAA Climate Explorer:
  >Adaptation and Resiliency>>Think Globally, Act Locally>>>Emergency Preparedness>>>>Weather Ready Nation Videos
  (also found here: https://www.meted.ucar.edu/emgmt/wxreadynation/launch.htm*)
- * This interactive teaching module was developed by Raytheon in partnership with NOAA's Weather Ready Nation program. Getting into the *interactive module* will require setting up an account and logging in. Then, you can select a grade-level and state to get the "required" and "elective" lessons. Each lesson takes about 8-10 minutes to play through.
  - Alternatively, the videos in the lessons can be downloaded and saved to play in the future without a login required.
- Each scenario will explain what to do BEFORE, DURING, and AFTER the severe weather event, and then test the student's retention of the information. This is an engaging way to communicate live-saving information. By connecting it to Climate Explorer and other locally relevant climate change impact information, it helps students to think critically about building community and individual resilience.
- Another way to teach this material without computer access is to download our Choose Your Own Misadventure activity, written by Groundwork Hudson Valley to facilitate conversation and critical thinking about hurricane winds, flash floods, and heat waves. The packet works like the choose-your-own-adventure books , requiring the reader to make decisions that will sometimes lead to dire outcomes for their character. This should be used only for audiences

V.C: Local Emergency Preparedness—Classroom Activity (page 3/3)

that are in Middle School and up. The "Choose Your Own Misadventure" activity packet can be found and downloaded at the bottom of this : http://www.groundworkhv.org/climate-change-resilience-learning-module/

- Once the students have finished either activity, they should be able to list three rules to follow BEFORE, DURING, and AFTER a natural disaster to ensure their safety. One such rule is to prepare an evacuation plan or an emergency kit.
- **Optional**:

ELABORATION (10-15 minutes plus set-up time)

- Using the Web-app, navigate to the following prep videos:

  >Adaptation and Resiliency>>Think Globally, Act Locally>>>Emergency Preparedness>>>>Simulated Hurricane Video
  (also found here: https://youtu.be/WXB1DQzvfxU)

  >Adaptation and Resiliency>>Think Globally, Act Locally>>>Emergency Preparedness>>>>Make an Emergency Plan & Kit (FEMA)
  (also found here: https://youtu.be/LviZ4pZrqu8)

- You can use the Simulated Hurricane Video as an opportunity to have students narrate the increasing intensity of the storm, the hazards that may face at each stage, and what choices the person should have made. For example:
  - **BEFORE**: Secure items outdoors, board up windows, protect vulnerable areas with sand-bag barrier walls or similar, garage your vehicle, raise utilities and valuable possessions if possible, have an evacuation plan and a 72-hour kit, evacuate if instructed to.
  - **DURING**: Stay indoors! (even when it gets calm suddenly—you are in the eye of the storm). Avoid windows and doors and electrical hazards. Shelter in a small room with more walls and possibly under a sturdy table. Avoid the basement if heavy rains and avoid the top floor if possible unless flooded out.
  - **AFTER**: Avoid flooded areas, electrical hazards, listen to NOAA hand-crank radio to get updates about conditions outside, have contact info and go-bag ready, a whistle and flashlight for signaling emergency responders.
- Download and print an emergency checklist, found on www.ready.gov, or here: https://www.fema.gov/media-library-data/1390846764394-dc08e309debe561d866b05ac84daf1ee/checklist_2014.pdf
  - You can assign a home scavenger hunt of these checklist items for homework (without students being obliged to find them all, as they might not yet own them)
  - OR you can buy most items from a dollar store and set them out ahead of time around the classroom, rec center, or other facility and give students a time-limit to find them all and mark where they were found and why they are necessary/useful.
  - Follow up with questions about family contacts and evacuation plans. Why is it much better to prepare these far in advance of any potential hazard?
  - Show them how to download and use the **FEMA app** for mobile devices, which features a buildable checklist, reminders for replenishing your kit or checking fire alarms, a natural disaster guide, local weather alerts, etc.

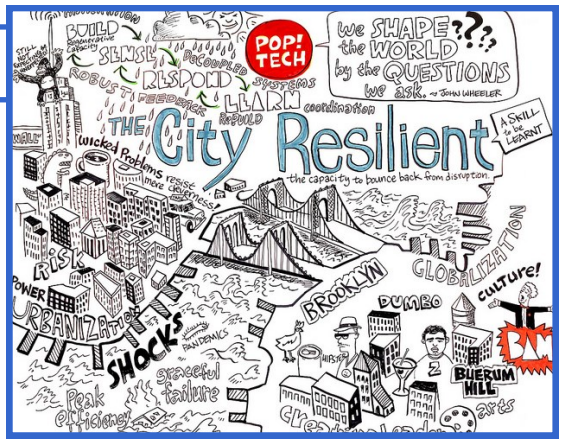
Receive **real-time alerts** from the National Weather Service for up to five locations nationwide.

Learn **emergency safety tips** for over 20 types of disasters, including earthquakes, fires, hurricanes, tornadoes and more.

Locate open **emergency shelters** in your area and find **disaster recovery centers** where you can talk to FEMA in person.

Toggle between **English** and **Spanish**.

V.D: Local—Designing Resilient Cities



Key Concepts and Web-app Resources:

In the past, the chance of disaster arising from a 500 year or 1,000 year storm event was a risk we were willing to take because the cost-benefit ratio was too great. Now, the mounting expenses from increasingly frequent "billion dollar disasters," coupled with human-driven climate change make inaction irresponsible and perilous. Disasters leave a trail of devastation that can lead to public health crises, disrupt business and everyday life, and limit social and economic growth. But, the new reality also presents an opportunity! Resilience planning and development can build a new, ***green*** economy—requiring city planners, scientists, hydrologists, farmers, architects, contractors, landscapers, energy companies, advertisers, public health workers, educators, media, industry, and government to work in concert with each other toward a sustainable goal! Great strides can be made by improving building and vehicle energy efficiency, reducing waste by finding ways to reuse and recycle consumer goods, construction materials, and organic scraps locally, and increasing greenspace in our cities.

According to the UN Department of Economic and Social Affairs, the world is continually urbanizing, challenging both aging infrastructure in *old* cities, and poorly planned layouts of rapidly developed *new* cities. By the year 2050, one third of human population will have moved out of rural areas and into the city over the course of a century. Our cities have the most at stake to gain **or** lose when it comes to adaptation and carbon mitigation efforts. Resilience planning necessitates serious investment of people-hours and capital but studies show that sustainable development can actually have economic benefits too, saving money in resource management, utilities, liability insurance, public health, and emergency response, while generating new jobs. Ultimately, each city will have to weigh its various stake-holders' interests and available capital against their particular vulnerabilities to determine the best resiliency plans.

Unit VD. Web-app Resources:

>Adaptation and Resiliency

>>Coastal Resilience

>>>**Coastal Resilience** (Nature Conservancy Video)

>>Think Globally, Act Locally

>>>Designing Cities for Resilience

>>>>**The Science Barge example** (Groundwork HV video)

>>>>**The EcoHouse example** (Groundwork HV video)

>>>> **Be Water Wise**

>>>**NOAA Resilience Toolkit: Climate Explorer**

V.D: Local—Designing Resilient Cities—Classroom Activity (page 1/8)

Lesson: Weighing stake-holder interests while planning for city resilience

******This lesson is adapted from the activity, Beat the Uncertainty, developed by NOAA and the Max Planck Institute for Human Development, found here: https://games.noaa.gov/beat-the-uncertainty/beat-the-uncertainty-instructions.pdf*

Subject / grade level: 6th-9th grade, all subjects

Materials: 4 copies of the Climate Change Resiliency Game packet, 4 pairs of dice, 4 pennies, bingo chip or similar size figurines (as game pieces).

Lesson objective(s): Students will understand the complexity of city resilience planning. By following a process, students will also develop critical thinking skills, learn how to assess community risks and prioritize stakeholder needs, and improve communication skills.

ENGAGEMENT (5 minutes)

- Ask students: What are the necessary steps a city must take towards a resiliency plan? They can shout out their ideas while you record them on a blackboard or over-sized notepad.
    - Examples: form a planning team, identify risk and vulnerabilities including social vulnerabilities, determine community stakeholder's needs, research solutions, set the goals, create a plan, budget, and timeline, gain public approval, implement and evaluate the plan, maintain and modify as needed.

EXPLORATION (40 minutes)

- SET UP: Print four copies of the Climate Change Resiliency Planning activity packet. Each should include a (1) Gameboard, (2) The map and background information for "Rivertown," (3) the Stakeholder's Perspectives Page, (4) the Resiliency Measures checklist, and (5) the double-sided Climate Cause and Effect page.
    - Highlight a different Stakeholder's Perspective for each packet so that each team will have a different approach to resiliency.
- Break the class into four teams. Give each team an activity packet, a game piece, and a pair of dice.
- Each team represents residents from "Rivertown"—a coastal city that is vulnerable to climate change. Collectively among the four teams, the players are the citizens, policymakers, business-owners, public-health workers or researchers—who together are responsible for making their city resilient to climate change. Each group, however, will be approaching resiliency from their own stakeholder perspective needs.
- First have a student read the background information on the map aloud to the class. Together, they should identify key vulnerabilities for Rivertown in three categories: SOCIAL, INFRASTRUCTURE, COMMUNITY RESOURCES.
    - **Social:** low-income families, aging homeowners, retirement home, immigrants with language barriers
    - **Infrastructure:** high percentage of impervious surfaces (roads, buildings, parking lots), Rivertown Train Station and tracks, water treatment plant, aging roads, culverts, and sewer system (combined sewage overflows), limited greenspace, retaining walls along Main Estuary, few evacuation routes out of the city can cause traffic in emergencies, energy lines
    - **Community Resources to Safeguard:** Public library, Hospital, supermarkets and other food hubs, Community Center, shelters, hydration stations, cooling centers

V.D: Local—Designing Resilient Cities—Classroom Activity (page 2/8)

- **Next**, tell each team to assign a leader to be the tie-breaker for any resilience planning decisions. They can now begin to read their team's highlighted shakeholder perspective. This is the approach they will be taking when they determine which resiliency measures to enact.
    - This part is designed to help understand different points of view. While some students may find one stakeholder more justified or important, it is important to keep in mind that every stakeholder has an objectively valid perspective—and that they all want to help build resiliency in their community. For the purpose of this activity, at least, no stakeholder is suggesting that climate resiliency planning be ignored.
- Tell the teams they have 7 minutes to discuss and decide how to spend their Rivertown resiliency planning budget of 70M credits, seeking to fulfill their stakeholder needs. (Students should be working off the Resiliency Measures sheet). They can record their Letter Codes for their chosen resiliency measures on the top of the Game Board page for easy reference.
- **GAME PLAY:** How resilient is your city?
    - Roll the dice, and then find the climate threat on the "Climate Cause and Effect" page that corresponds to the number rolled. For instance, if you rolled two fours, you would look for number eight: "Extreme Flooding."
        - Read the Climate Cause and Effect. First move your game piece FORWARD according to the directions for that hazard. (For instance: Extreme Weather—high winds take out power lines: FIRST ADD 2).
        - Next, see if your chosen resiliency measures spared you the full impact. Move BACKWARD on the game board accordingly.
        - Mark Round 1 at the top of your Game Board with a CHECK.
        - Continue rolling the die and seeing how Rivertown is impacted by future climate uncertainty. Be sure to mark each round with a check before rolling the dice again. The game ends when either time is up, you make it to Round 14, OR your game piece reaches the deep red "Game Over" space by the end of the round.
    - When all the teams are finished playing, ask the team leader for each to recap their stakeholder perspective, their choices, and what their Final Score was. What might the do differently?
- **Discuss**: Why is it important to weigh many stakeholder perspectives when determining the best course of action for a resiliency plan?
    - How important to scientific data and expert consultation to the process?
    - Would they want to spend more or less than their budgeted 70M credits on resiliency planning if they could?
    - What obstacles do the students think city planners and communities face when trying to budget for resilience?

Resiliency Game Board

My approach was: _____ My resiliency measures included _____

Rounds: (fill in as you go) See how many you last for! (hint: keep track of resiliency choices by copying letters above)

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭

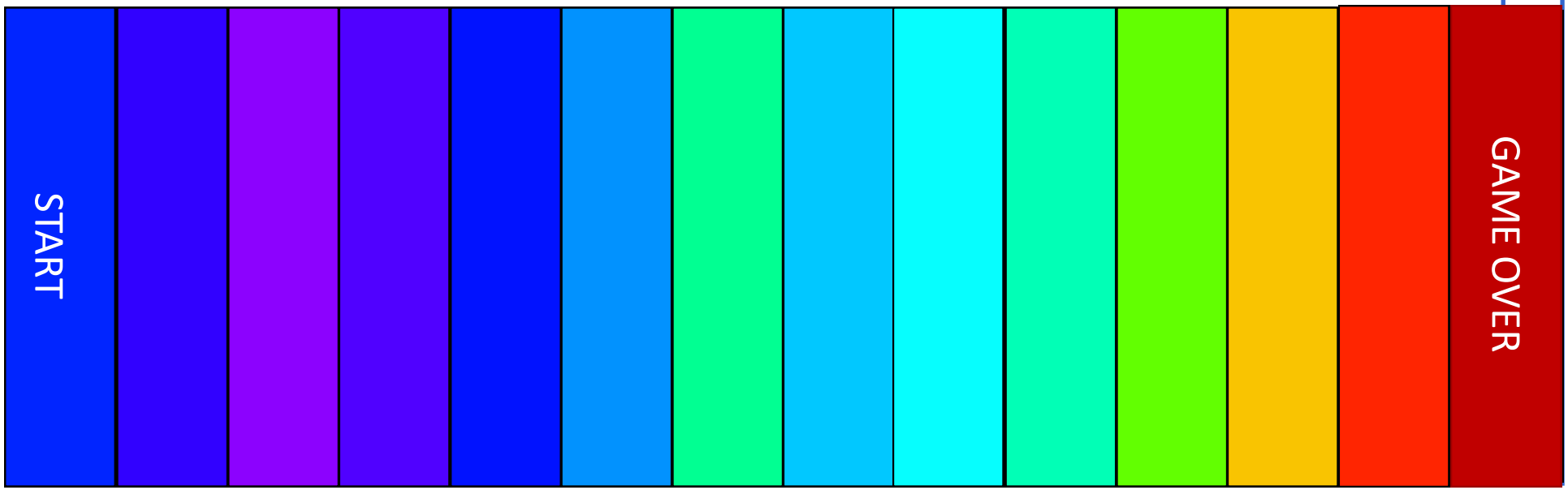
A warming planet, is a more vulnerable planet.

This color chart—based on deviations from global temperature averages every decade for the last 120 years—shows our pattern of accelerated warming since the industrial revolution. Use this as a game board, moving spaces forward with your game piece (to the right) as you ADD points from climate change impacts and moving spaces backward (to the left), as you SUBTRACT points from resiliency and mitigation measures.

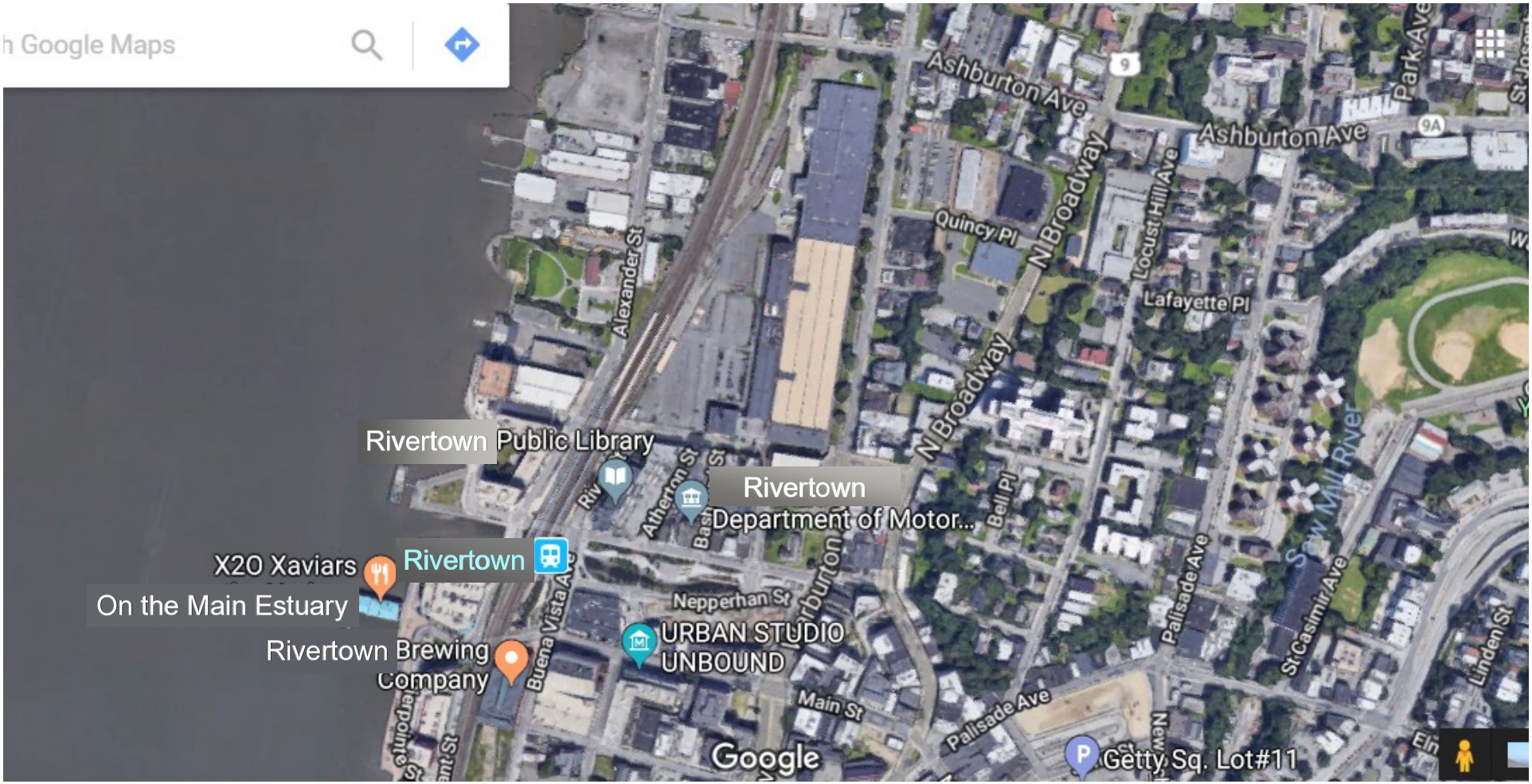
Keep track of how many rounds you last above. Once you hit the deep red…. GAME OVER.

SCORE:

1-4 Rounds—At Risk City **5-10 Rounds—Fairly Resilient, needs additional planning** **11-14 Rounds—Climate Smart City**



Background: Last year, Hurricane Harold and other heavy rain events have exposed Downtown Rivertown's aging Infrastructure. Harold, a category 3 storm, caused a 6 ft storm surge on the Main Estuary waterfront that flooded into the library, train station, and nearby restaurants and apartment buildings. It also caused many power outages in public housing units. Furthermore, more frequent heavy rain events have caused landslides that severely damaged the Retirement Home on Ashburton Avenue, flooding of the parks, and combined sewage overflows into the Tributary River and Main Estuary. Despite this, development is on the rise, with new high-end apartments and retail spaces being built close to the waterfront. Resources for the aging homeowner population, and lower-income families living in the downtown—such as health centers, affordable/accessible grocery stores, parking, subsidized housing, and affordable transportation are seemingly on the decline. Greenspace is also limited, with most of the shoreline built up and walled in.



Developers:

Rivertown is ripe for development. The Riverline Train station is nearby and with lower taxes than Metropolis, commuters can afford to live on the Rivertown's waterfront and commute into the big city. The fine dining restaurants in Rivertown, like X2O and Dolphin are looking forward to more new customers, and new high-end retail stores are being planned for the strip. Flooding by the waterfront is a big concern for the new apartments.

Homeowners:

Rivertown's waterfront has an aging homeowner population. With rising insurance rates, cost of food and transportation rising, and more frequent heavy storms, many are considering selling to developers and looking for subsidized public housing or retirement homes to live in. Power outages are a big concern, as many are medically dependent on electricity and means of communication. Infrastructure for flood protection might help alleviate cost of damages and insurance rates.

City Government:

With so much spending and development, and more frequent infrastructure damage by severe storms, Rivertown's budget is strapped. Ironically, this means there is limited funds for investing in long-term solutions for sea-level rise and storm surge along the Estuary, or flood protection along the Tributary. The roads are aging poorly from too many harsh winter storms and have many potholes, and trash in the street has clogged storm-drains. The city looks forward to new tax income from new residents in high-end housing units to help rebuild the roads, etc.

Public Housing Residents:

The cost of living in Rivertown is going up, making it harder all the time to afford food, transportation to work, and rising rents. Youth see little future in Rivertown for job training pathways or positions with decent wages after HS or College. There are few social and cultural spaces and limited greenspace access. Utilities in the basements make these buildings very vulnerable to flooding. Emergency preparedness is not widely known or prioritized.

Climate Change Resiliency Game

	Resiliency Measure	Cost	Your Selection
A OR B	Develop a soft coastline (e.g. using carefully managed wetlands) for protecting against the effects of storms and sea level rise.	25M	
	Build a hard coastline (e.g. using levees) for protecting against the effects of storms and sea level rise.	20M	
C	Require that new city sidewalks and pavements be made from permeable materials, in order to absorb stormwater. Add greenroofs.	5M	
D	Fund a "Youth Green Corps" initiative to develop and maintain green-spaces in the city. Greenspace can serve as (a) heat absorption/ reduction of urban heat island effect, (b) water absorption to reduce flooding (c) carbon sequestration to mitigate our footprint.	10M	
E	Create early warning systems to warn citizens of impending hazards.	10M	
F	Form evacuation plans and run a public preparedness campaign for responding to extreme events. Run drills with emergency responders.	15M	
G	Invest in infrastructure that is more storm resilient. E.g.: raised buildings to let floodwater flow underneath, underground power lines, and outdoor structures resilient to more powerful winds.	25M	
H OR I	Allow building in coastal areas that are rarely affected by floods now but may be in coming decades, in order to strengthen the economy in preparation for climate change impacts.	10M REBATE!	
	Devise policies to discourage building around coastal areas and prevent development in storm surge-prone areas.	5M	
J OR K	Update all storm drains, sewers, and drainage ditches, to add room for unpredictable increases in stormwater runoff.	25M	
	Create Bioswales and Vernal Ponds to absorb and hold water in heavy rain events near roads and building complexes prone to flooding.	15M	
L	Retro-fit vulnerable public housing complexes and municipal buildings (including libraries, hospitals, etc.) to have utilities moved off the basement and first floors and higher up to avoid floodwaters.	20M	
M	Create a more localized power grid that includes rooftop solar panels, geothermal, wind turbines along the Palisades, and biodiesel backup generators to reduce the carbon footprint and ensure power is locally available even after extreme weather events and "brown-outs."	25M	

Do not exceed 70M Credits

Roll the Dice!	Cause and Effect!
2	**Green Growth** **SUBTRACT 1:** Your community has embraced green infrastructure so resilience policies are easier and cheaper to pass and implement!
3	**Heat Wave—increased heat stroke: FIRST ADD 1** **SUBTRACT 1 if you chose TWO of the following**: **A** (soft coastal barrier), **D** (greencorps), **E** (early warning), **M** (local energy to safeguard against brown-outs).
4	**Favorable Conditions** **SUBTRACT 2:** Your population is less vulnerable to extreme weather. Your government has saved resources to deal with future extremes.
5	**Storm Surge: Extreme Severity—levees fail: FIRST ADD 5** **SUBTRACT 1 for each of the following you implemented:** **A** (soft coastal barrier), **D** (green corps), **E AND F** (early warning and evacuation), **G** (raised buildings), **I** (discourage coastal development), **J OR K** (flood drainage plans), or **L** (retro-fit building utilities). **ADD 1** if you selected **H** (allow coastal development).
6	**Marine Dead-zones from Runoff: FIRST ADD 3** More rain causes nutrient runoff from lawns, farms, and sewage-overflow to deposit into rivers and lakes, causing massive fish die-offs, hurting the economy. **SUBTRACT 1 for each of the following you implemented:** **C** (permeable streets) **D** (green corps), or **J** (margins on drainage) .
7	**Heavy Rains & Storm Surge Cause Flash Flooding: FIRST ADD 2** **SUBTRACT 1 for each of the following you implemented:** **A or B** (coastal barriers), **C** (permeable streets), **D** (green corps), **E** (early warning), **G** (raised buildings), **I** (discourage coastal development), **J or K** (flood drainage plans), L (retrofit buildings). **ADD 1** if you selected **H** (allow coastal development).

Roll the Dice!	Cause and Effect!
8	**Extreme Weather—high winds take out power lines: FIRST ADD 2** Power loss can cause disruption to transportation, commerce, communication, heating/cooling, cooking, and health-care, compromising wellness, safety, and the economy. **SUBTRACT 1 for each of the following you implemented: G** (resilient infrastructure), **M** (localized energy).
9	**Moderate Flooding from Extensive Rain: <u>FIRST ADD 2</u>** **SUBTRACT 1 if you chose <u>TWO</u> of the following**: **A** (soft coastal barrier), **C** (permeable surfaces), **D** (greencorps), **J or K** (flood drainage plans), or **L** (retrofit)
10	**Fewer Coastal Extremes** **NO CHANGE:** Your population is less vulnerable to extreme weather for a few years.
11	**Storm Surge: Normal Severity—levees not breached: <u>FIRST ADD 3</u>** **SUBTRACT 1 for each of the following you implemented:** **A or B** (coastal barrier), **D** (green corps), **E** (early warning), **F** (evacuation), **G** (raised buildings), **I** (discourage coastal development), **J OR K** (flood drainage plans), or **L** (retro-fit building utilities). **ADD 1** if you selected **H** (allow coastal development).
12	**Climate Literacy Improves** Citizens make more informed decisions, helping them to protect the community! **SUBTRACT 2 for each of the following you implemented:** **D** (green corps), **F** (public preparedness campaign), or **I** (smart policies on coastal development).