HARDING CENTER FOR RISK LITERACY

Max Planck Institute for Human Development

Beat the Uncertainty: Planning Climate-Resilient Cities

Background

This simulation was adapted from an original activity by Tarlise Townsend and Astrid Kause and was later adapted to a coastal version for Vietnamese audiences with Peg Steffen, NOAA National Ocean Service, Dinh Thai Hung, Thanh Ngo Duc, and Vinh Nguyen Le Ai. In 2015 it was adapted for an American audience with the assistance of Susan Fox at NOAA's Office of Coastal Management.

You and your fellow players are the leaders—citizens, policymakers, business leaders, nonprofit leaders, and researchers—of a coastal city. You are excited about the potential to make the city a better place, but you also facing many challenges. One of these is climate change.

One impact of climate change is rising sea level, which puts your city at risk of more flooding and of saltwater getting into your soil and freshwater supply. Other effects of climate change in this city include more severe hurricanes, more heat waves, and heavier rainfall in the rainy season.

Your job is to make smart decisions that will increase the city's resilience to climate change. The problem? You do not know exactly what impacts climate change will have on your city, how severe they will be, or when they will occur.

Materials

The following are the materials needed for *one station*. Up to five players can use one station, although the game probably works best with three or four players per station. The stations are independent of one another, so any number of stations can be used. Each station needs:

- One Resilience Measure Checklist
- One Climate Events Booklet
- One medium- or large-sized plastic food storage container.

- One smaller plastic container that sits upright, floats, and fits inside the vase. This is your “boat”. A small condiment container works well.
- Enough water to fill the plastic container halfway. This is your sea. It will change levels to represent sea level rise.
- Blue and green food coloring to dye your seawater if desired.
- Craft materials for decorating the sides of the large container to represent your city’s “coastline” (e.g. crepe paper, glue, and scissors). You can also print out a strip of coastline using Clip Art and tape it onto the side of the container.
- About fifteen glass floral beads with flat bottoms. These will be gradually placed into the boat when players make decisions that are not resilient to climate change impacts. The flat bottoms will prevent the shifting.
- Two six-sided dice.

Setup

1. Decorate the outside of each large container to represent the city “coastline”. The bottoms of the buildings should be in a straight line, about an inch above the container’s midline. Instructors can do this in advance or players can create their own coastlines.
2. Add water to the large container until it is about an inch below the coastline, i.e. about halfway full.
3. Add food coloring to the water to create the desired “seawater” color.
4. Run through the game to ensure that the boats will float when up to 12 marbles are added. When more than 12-15 marbles are in the boat, the boat should sink. Calibrate as needed.
5. Place the Resilience Measure Checklist and booklet at the station. Ensure that players keep the booklet closed until after they have made their resilience decisions!

How to Play

Each station represents a coastal city that is vulnerable to climate change. The players at that station are the city’s decision makers—citizens, policymakers, businesses, civil society, and researchers—who together are responsible for making their city resilient to climate change. First, they will work together to decide how to spend their limited funds available for this purpose. Then they will put those decisions to the test!

1. **Design your own climate-resilient city.**

   Each team should examine the Resilience Measure Checklist. 70 million credits available to spend on resilience measures. What combination of measures will best protect your city from adverse impacts of climate change?

Each team should take up to ten to fifteen minutes to discuss the strategies and write their selections on the checklist. Remember, the total cost of resilience measures cannot be more than 70 million credits!

Depending on the background and age group of the students, instructors can decide whether to provide some additional explanation of each measure at this point or whether to save instructor input for the debrief session.

2. **Find out: how resilient is your city?**

   Roll the dice, and then open up the Booklet to the climate threat corresponding to the number rolled. For instance, if you rolled two fours, you would open the booklet to the number eight: "Flooding" (normal severity).

   Now, look at the resilience measures listed on that page. Under "The Good" are measures you might have taken that would make your city more resilient to this climate impact. Some pages also have a category called "The Bad". These measures would actually make your city less resilient to the climate impact you rolled!

   Which of the listed resilience measures did your city select? Check them off in the booklet. If you only selected "soft coastal barrier" and "allowing coastal building", you would check those boxes and leave the others blank.

   In the space provided, write the number of "good" measures that you selected. Place the corresponding number of marbles into your boat. In our example, you would put five marbles into the boat because you only selected one good resilience measure. Finally, add another marble if you selected a "bad" resilience measure.

   As you add marbles, notice that your boat displaces more water, causing the boat to sink and the sea level to rise slightly—inching closer to your city's coastline. This represents a growing threat of climate change! This is not because your less resilient decisions actually *cause* climate change—but rather because they make your city less able to withstand its impacts. Notice that the more "good" resilience measures you select, the fewer marbles you have to add.

   Roll the dice again and repeat! Keep playing until your boat sinks.

<u>How to Win</u>

How many climate change events (dice rolls) until your boat sank?

- More than 12 rolls: You are Masters of Resilience!
- 10-12 rolls: You designed a very resilient city—next time I bet you'll be Masters!
  7-9 rolls: Your city withstood some climate impacts but not others. Where could you have improved your decisions?
- 4-6 rolls: Your city was very vulnerable to climate change. Why do you think that happened?
- 1-3 rolls: Are you just trying to splash in the water?

Debrief

1. *What does this uncertainty have to do with climate change?*

In this game, you did not know exactly what climate events your city would experience at any given time. If it was your first time playing, you did not even know how likely the any given event was. The impacts of climate change in the real world will be similarly uncertain. Not only can we not predict with certainty what climate event will occur when, and with what severity, in any given location; we cannot even assign exact probabilities to different possible events. We call this "uncertainty", and distinguish it from "risk". With risk, we can calculate the probabilities of different outcomes.

Insurance companies regularly calculate the probability of a person getting into a car accident. They use extensive data on past events to predict the future. Climate change is taking the climate system into new territory, so that what happened in the past does not necessarily predict the future. Probabilities are much harder to obtain, and so we face more uncertainty than before. Since they cannot assume the future will look like the past, scientists plug their understanding of the climate into models, which then make predictions about future events and trends. The problem is there a good deal of uncertainty in those models as well.

Traditional approaches to risk management often involve a cost-benefit analysis, weighing the probabilities and costs of different outcomes in order to calculate the safest best. With climate change, though, we usually cannot quantify those probabilities—there might be a wide range of plausible outcomes, and it is not obvious which one we should prepare for.

This has all kinds of implications for cities. How high should we build the levees if we do not know what floods will look like in the coming decades? Will sea level rise really be bad enough to merit retreating from the coast? Should we invest in an expensive infrastructure project that would protect against extreme weather events? Decision strategies that require quantified risk are often insufficient to answer these questions. Instead, we need strategies that are flexible to the uncertainties. The game challenged you to think about what those strategies are.

2. *What might be some strategies for dealing with the uncertainty in climate impacts?*

- **No-regrets strategies:** Choose strategies that prepare for the available forecasts, but that offer benefits even if an event forecast or predicted timeline proves inaccurate. For example, limiting building in flood-prone areas would reduce damages in the current climate—and would be all the more beneficial in the case of sea level rise.
  For example, resilience measure *C* offers a variety of benefits. Green space absorbs more water than typical impermeable concrete or paved surfaces, which can help to assuage flood events. It also reduces the urban heat island effect that causes a city to heat up more than non-urban areas. It helps with carbon sequestration, helping to mitigate climate change, and offers citizens a place for recreation, access to nature, and a break from the busy city. So even if flooding due to climate change isn't ultimately severe in the city, the green space provides a number of other important benefits. Resilience measures *A* and *D* are other great examples of no-regrets strategies.
- **Flexible and reversible strategies:** Decisions that can be adapted or reversed as the available information evolves are more climate resilient than those that cannot.
  Resilience measures *H* and *I* demonstrate this distinction. Both have advantages and disadvantages: developing in areas that may become more flood prone due to climate change has short-term economic benefits but, in the long term, economic and health risks. Discouraging development means losing out on the short-term benefits but reducing climate change vulnerability. Since the future climate impacts are uncertain, choosing the reversible path may be best: reversing the decision *not* to develop is much easier that reversing the decision to develop.
- **Safety-margin strategies:** Incorporating more room for error into an urban planning project can be a cheap way to add resilience to the system.
  Resilience measure *J* is an example of a safety-margin strategy. In a city expected to experience more flooding due to sea level rise or increased rainfall, the amount of water flowing into the drainage infrastructure may sometimes be higher than predicted. Adding a safety margin helps to prepare for this uncertainty.

3. *In the real world, there are many factors at play beyond the immediate expense and climate vulnerability. Can you think of some others that would likely influence the resilience measures a city decides to take?*

- **Economic incentives:** Green space offers a wide variety of benefits for a city, as discussed above. A large park may occupy prime real estate, and developers might pay a lot of money for building there. Decision makers and citizens may believe that allowing this would bring needed resources to surrounding neighborhoods and the city overall.

- **Competing interests:** In every city, there are more challenges than there are resources. While some groups may be greatly concerned about climate change impacts, others may believe that other issues are more important and deserve greater attention. Each may advocate their position to decision makers. Deciding how to allocate the funds, time, energy, and expertise across myriad issues is a continual process.

- **Psychological biases:** Many factors influence our response to climate change. For instance, the fact that many of its impacts will occur over a span of decades activates present bias. Present bias occurs when we overvalue the present (or short-term) compared to the future (or long-term). For instance, we may choose to avoid the inconvenience of creating climate resilience societies now, even though it would likely entail very large benefits in the future—and even though the benefits would probably be larger than the costs.

- **Status quo bias** is also at play in climate change decision making. In status quo bias, people prefer the status quo over change, even when the status quo is objectively inferior. This may partly explain why it has been so difficult to motivate behavioral change in the face of climate change.

- **Individuals also experience ambiguity aversion**, in which they prefer known risks to uncertainty—even if the known risks are not in their favor. This game aims to make players aware of uncertainty and to provide strategies for dealing with it, in the hope that this can help combat ambiguity aversion in the context of climate change.

4. *Are the dice the best analogy for climate uncertainty? Why or why not?*
Since you can actually calculate the probability of any particular dice roll, the dice do not perfectly represent climate change uncertainty *if* you know which climate event corresponds to each number rolled. This is why it was important that you not look at the climate events booklet before choosing your resilience measures! Not knowing the probability of each event forced you to select measures that would be resilient to a variety of possible outcomes.

Discussion Notes after the first simulation. After discussion, try the simulation again with different coastal strategies.

A) *Develop a soft coastline (e.g. using carefully managed wetlands) for protecting against the effects of storms and sea level rise.*

Wetlands offer flood and storm protection, erosion control, and carbon sequestration. They also serve as habitat for wildlife, provide recreation area for local citizens, and help to filter contaminants out of water before flowing into the ocean.

B) Build a hard coastline (e.g. using dams, seawalls, and levees) for protecting against the effects of storms and sea level rise.

Hard coastlines also offer flood and storm protection. However, they have fewer co-benefits than soft coastline—and can actually worsen coastal erosion. A hard coastline may also be less resilient to uncertainty. It may protect the city up to a certain point, but then fail if, for instance, storm surge exceeds that level. Once a breach occurs, a hard coastal barrier may actually impede outflow of water from the city.

C) Increase amount of green space in the city to serve as (a) heat absorption/reduction of urban heat island effect, (b) water absorption to reduce flooding (c) carbon sequestration.

This measure not only increases resilience to climate change, but it also aids in climate change mitigation efforts by storing carbon—not to mention the benefits to citizens of having park space for exercise and recreation.

D) Require that construction of new city sidewalks and pavements use permeable materials in order to absorb stormwater.

Traditional concrete and asphalt absorb very little water. When it rains heavily or floods due to sea level rise, the water runs off these surfaces and into the city's drainage system. Introducing permeable surfaces into cities helps to reduce the burden on the drainage system, making flooding less likely or severe. By allowing water to seep into the ground, permeable surfaces also reduce city temperatures, decrease pollutant transport (via filtration in the earth), and aid irrigation of surrounding land.

E) Create early warning systems to warn citizens of impending hazards.

This measure highlights the fact that reducing vulnerability to climate change is about more than a city's physical resilience; it is also a social phenomenon. The ability of citizens to respond to an impending hazard is just one example of social resilience. Others include increasing the ability of the health system to manage the fallout of an extreme event, and improving the overall health, education level, and economic stability of the population.

F) Complete evacuation and preparedness plans for responding to extreme events. Run drills and make sure the public knows the plan.

In this game, the benefits of resilience measure *E* occur if players did not also select measure *F*. If citizens receive a warning about the hazard but cannot effectively evacuate or respond to it, the warning does little good. This was included to emphasize the importance of planning for an entire chain of events—rather than just one addressing one link in the chain.

G) *Build buildings that are more flood- and storm resilient, e.g. buildings are raised so water can flow underneath.*

Such buildings can reduce damage due to floods. However, this measure will not protect existing buildings and it has fewer co-benefits than some of the other strategies.

H) *Allow building in coastal areas that rarely flood now but may be in coming decades, in order to strengthen the economy in preparation for climate change impacts.*

This has economic benefits that could be used to invest in other resilience measures. However, it will also increase vulnerability to climate change by putting individuals' homes and businesses at risk of flooding. Decision makers must weigh the advantages against the disadvantages.

I) *Devise policies to discourage building around coastal areas and prevent development in flood-prone areas.*

This is, in effect, the opposite of measure *H*. These measures raise awareness of the economic tradeoffs when investing in resilience, and the difficulty of comparing short- and long-term outcomes.

J) *When updating the storm drains, sewers, and drainage ditches, add some wiggle room in how much water they'll tolerate—in order to prepare for unpredictable increases in stormwater runoff.*

An unexpected increase in heavy rainfall could overwhelm the systems that manage the stormwater flowing on city surfaces, thereby increasing the likelihood of flooding. In a city where rainfall and/or sea level rise increases the flow into this system, its capacity should be increased. Including "wiggle room" can help a city deal with the uncertainty about exactly how large that increase will be.

K) *Build water reservoirs that are protected from saltwater intrusion, since sea level rise threatens saltwater intrusion into underground aquifers.*

As sea levels rise, seawater can infiltrate the aquifers that store freshwater underground, threatening the water resources needed for drinking and agriculture. One solution is to store freshwater in more protected reservoirs. However, this measure is expensive and may not be optimal.

L) *Subsidize bottled water for citizens whose water comes from aquifers vulnerable to saltwater intrusion. This will get them in the habit of drinking it now.*

This is not an optimal resilience measure. Rather than working to prevent saltwater from infiltrating drinking water sources, it assumes the aquifers will be affected and offers an unsustainable solution to that challenge. Producing bottled water itself uses a good deal of water, thereby putting more pressure on the earth's already scarce freshwater resources.