Instructor Teaching Notes: When It Rains, It Pours: A Socio-environmental Approach to Understanding Urban Coastal Flooding

1. Title: When It Rains, It Pours: A Socio-environmental Approach to Understanding Urban Coastal Flooding

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3. Abstract

This case is an introduction for students on socioeconomic systems using coastal flooding as a model system. The students are presented with the real case of Miami Beach, in South Florida, which is experiencing increased flooding, both at higher high tides and with storm surge. The case has three activities which instructors can choose whether they want to use all or some of these activities. The first activity is designed to provide a guided introduction to socio-environmental conceptual modeling for students with no previous background. The second activity is a conflict negotiation for upper-level undergraduate students or graduate students. The third activity is a group project where the students write a decisional memo as a team.

For all activities in this case study, students will be expected to work in teams. In the first activity students develop a conceptual model in small groups, again in synthesis groups, and then finally together as a class. For the conflict negotiation activity, students research the interests of a stakeholder group to role-play a flood management group decision-making process. For the group decisional memo activity, students continue to play their role from the negotiation activity and ensure that those viewpoints of each stakeholder are included in the decisional memo to Miami Beach leadership about what investments the city should make to decrease coastal

[1] Updated by Sutton-Grier, Kenney, and Albright August 2015 after teaching the activities in Spring 2015. The update includes Activities 2 and 3, which are new additions to this version of the case study, as well as example student work and additional thoughts after teaching the activities in a classroom setting.

flooding in the community. The case is designed primarily to be coupled with formative assessments as the students prepare and complete the exercises in class but the decisional memo is a final summative assessment of all the students learned throughout all the case study activities.

4. What course(s) is this case appropriate for?

This case study was designed by a multidisciplinary team representing several disciplinary fields (including the social and natural sciences). Therefore, the goal was to create an interdisciplinary activity that could be used across a variety of courses and a diversity of students. This case study is meant to be an introduction for students on what socio-environmental systems are and how to work in a socio-environmental system framework using coastal flooding as a model system. Course examples include:

- Introduction to Environmental Science and Policy
- Issues in Environmental Science
- Environment and Society
- Hazards and Society
- Environmental Decision Making
- Conflict Resolution
- Social Perspectives in Environmental Issues

5. What level is this case appropriate for?

This case study targets students enrolled in higher education in a myriad of institutions. The first activity is written with introductory students in mind (freshmen and sophomores) but also works with upper level students and even graduate students. The second and third activities may be best suited to upper division undergrads or grad students. Instructors should determine the level of help her or his students will need based on their backgrounds and previous coursework, so instructor discretion is needed.

For the first activity, the students will be expected to work in teams to develop a conceptual model in small groups, again in synthesis groups, and then finally as a class. The instructor will need to facilitate the group work (making sure students are working well in teams and generally understanding the central themes) and will need to facilitate the class discussion to ensure that the learning goals are reached. In particular, the instructor should emphasize that there are multiple concept maps that could be developed depending on different perspectives and there is no one "right" concept map. The instructors also can assure that the students understand how environmental and social systems are connected (this could include a discussion of indirect and direct relationships).

6. Socio-Environmental Synthesis (SES) Learning Goals- which SES goals are addressed in this case?

Learning Goals for Socio-Environmental Synthesis:
1. **Understand the structure and behavior of socio-environmental systems.** Meeting this goal is the main purpose of these exercise.

Learning Objective 1, Activity 1: Students will first develop a simple version of the system focused only on the social or environmental components of the system. Then working in "synthesis groups" with representatives from both the social and environmental science groups, students will develop a more complex conceptual map that includes both social and environmental factors and the connections between these components. Students will develop a conceptual model of a socio-environmental system -- the Miami Beach community. First instructors will lead a guided class discussion of the key elements of this system. Then, in teams of either environmental scientists or social scientists, the students will put together models of the Miami Beach environmental or social system related to coastal flooding. Next, students will get together in integrated groups (social scientists and natural scientists) to develop a more complex model of the socio-environmental system by combining models.

Learning Objective 1, Activity 2: The focus of this activity is to understand the nature of policy negotiation given biophysical and social scientific information and diverse stakeholder values. In order to develop solutions that would balance the perspectives of the different stakeholder goals, the students have to think through a range of grey, green, and hybrid infrastructure options to enhance coastal resilience understand the potential consequences (good and bad) of the different solutions. This is a higher level socio-environmental activity because it requires a recognition of scientific facts or projections, value judgments, and the decision space where these facts and values are combined.

2. **Consider the importance of scale and context in addressing socio-environmental problems.**

Learning Objective 2, Activities 2 and 3: To develop coastal resilience solutions that balance competing stakeholder objectives, an understanding of the decision context and the scale (spatial and temporal) of positive and negative impacts of different solutions are necessary for a successful negotiation and decisional memo.

3. **Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.**

Learning Objective 3, Activity 1: The focus of this exercise is for students to recognize different approaches and data that would be of interest to environmental or social scientists and to develop a conceptual model that includes both components and connections between these factors. To gain an understanding of the different kinds of environmental and societal information needed to understand an environmental problem. And gather relevant information from multiple disciplinary perspectives to holistically evaluate the environmental problem. Students will take the perspective of either an environmental scientist or a social scientist and develop a conceptual model of the Miami Beach community flooding issue. Then students will come together with 2 others from the alternate perspective to form a more complex conceptual map of the socio-environmental system of the Miami Beach area, with a focus on flooding.

4. **Find, analyze, and synthesize existing data, ideas (e.g. frameworks or models), or method.**

Learning Objective 4, Activities 2 and 3: In order to successfully understand the stakeholder values, the students will need to do independent research to understand their stakeholder's perspective, the potential solutions that would be desirable or undesirable given their perspective, and the socio-environmental information that is necessary to understand the positive and negative consequences of different acceptable solutions. They also need to understand how to professionally question different information and values that are proposed by different stakeholder groups in the classroom negotiation or in the group decisional memo. This does not necessarily mean that students needs to analyze datasets, but they do need to synthesize information that already exists, consider different ideas and solutions, and determine options that would balance the goals of different groups and would be likely (i.e., scientifically feasible) to produce the desired outcomes.

7. Classroom Management

Activity 1: Conceptual Mapping

Activity 1 is designed to be completed within two 75 minute classes but could be split between three 50 minute class periods. Before class, students should read the handout which provides background on the Miami Beach flooding challenges (contained in the "Urban Flooding Miami Beach Student Handout" file). Instructors may also assign further background reading (see annotated References) or even require the students to do some independent background research, but this is not necessary. Part I and Part II can be fit into one 50 min class or ideally into a 75 min class. Part III will take another 75 mins class or could be split between two 50 min class periods.

Part I: This case study begins with a brainstorming activity where we work with the students to introduce the idea of concept maps through a case example. The instructor asks the the whole class to think through several questions: What factors affects flooding? Who is affected by floods? What is affected by floods? Students are likely to come up with suggestions such as homes and businesses are flooded, roads are flooded, people may be stranded or even drown, emergency workers will be called in, etc. Once there are lots of ideas on the board, the instructor can start to help the students determine which ideas fit into common themes of:

- Communities
- Governance
- Culture
- Economics
- Built Environment
- Storms
- Coastal Ecosystems
- Sea Level Rise

The instructor can help the students think through how these concepts can be grouped together; for example, what can be grouped under "built environment" versus "economy." And if there are major categories of groups missing, the instructor can ask leading questions to get the students to

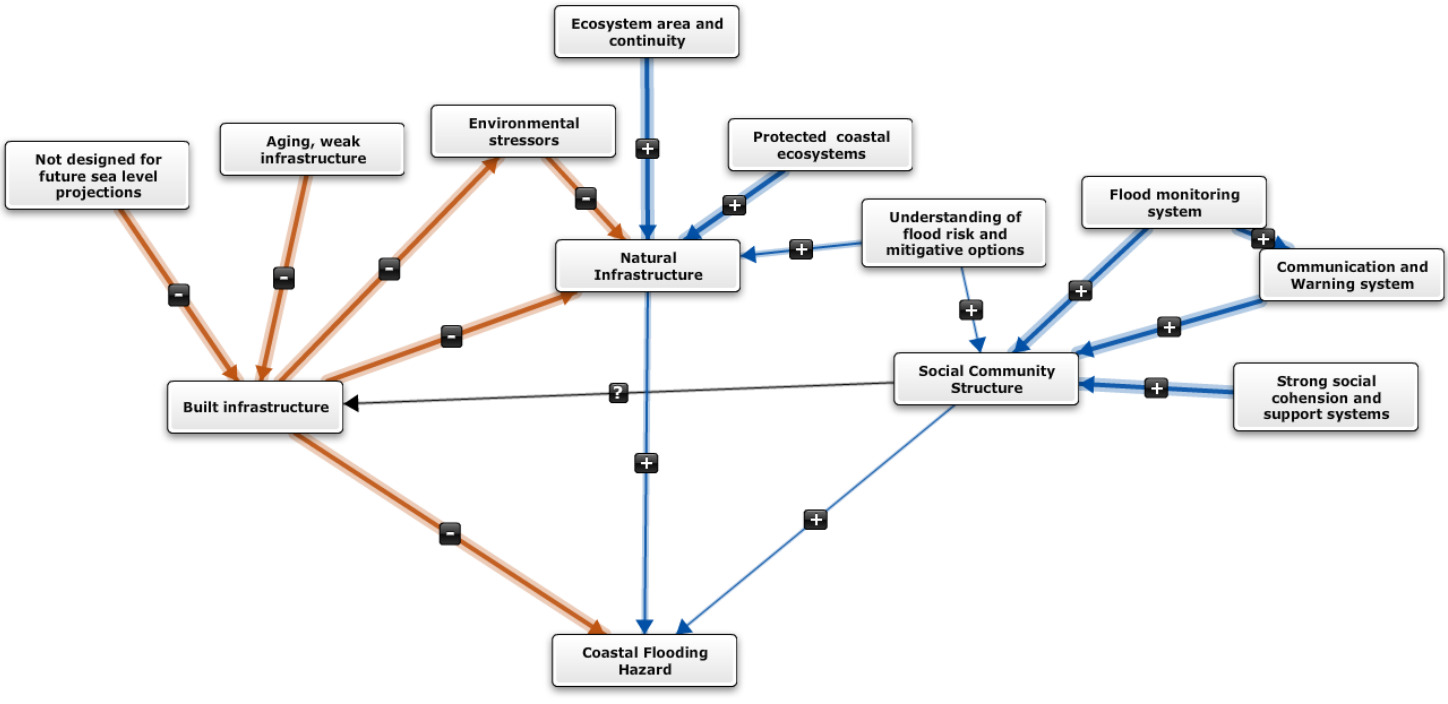
think about them such as, "Do coastal ecosystems play a role in flooding? If so, how?" Part I should take approximately 20 minutes.

Part II: Once the concept groupings are established, students break up into groups of 3-5 and either choose or are assigned to be environmental scientists or social scientists. The instructor provides sticky notes and a blank piece of paper (or alternatively, if white boards are available, students can use the sticky notes and white boards) and asks them to build a concept map (the initial ideas were presented and discussed during Part I of the exercise) of how the boxes (the themes identified during Part I which should be written on the sticky notes) relate for environmental science (built environment, storms, coastal ecosystems, sea level rise) or social science (communities, governance, culture, economics, built environment). For an example concept map see Figure 1. And for more information on what concept maps are and how to use them, see Novak, J. D. & A. J. Cañas (2008) in reference section. The student concept maps should include arrows suggesting relationships between the specific environmental or social science boxes and estimates of the particular relationship of the arrow to the boxes. For example or use of similar language, we suggest the use of the following terms for a relationship of Box A → Box B:

- Positive (+): An increase in Box A has an increasing the impact on Box B;
- Negative (-): An increase in Box A has a decreasing impact on Box B;
- Mixed (+/-): A change in Box A can either have an increasing or decreasing impact on Box B depending on different conditions; and
- Unsure: The relationship between Box A and Box B is uncertain.

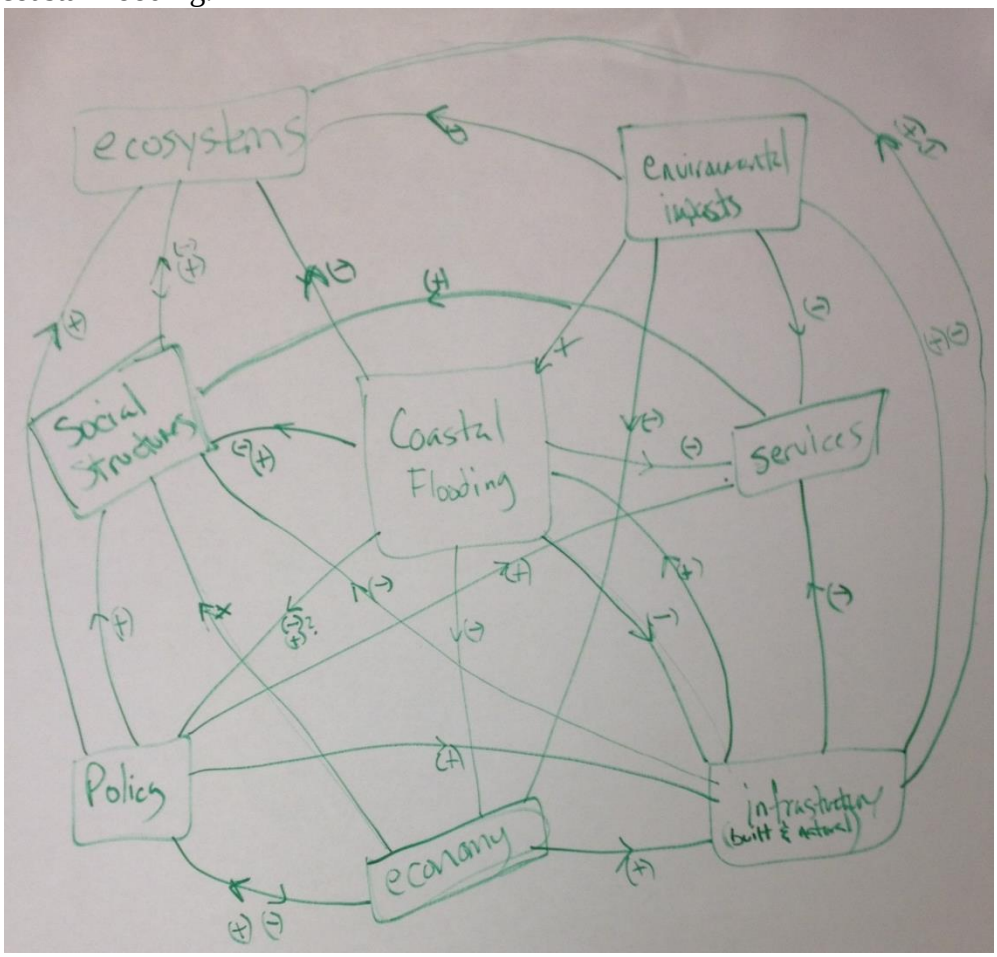
Instructor walks around the room listening in on each group's conversation making sure that group dynamics are working (i.e., that one student is not dominating the conversation and that all students are participating).

Figure 1a: Example of a concept map developed using the online platform of Mental Modeler (http://www.mentalmodeler.org/online/) showing relationships between environmental and social factors that affect or are influenced by coastal flooding. Mental Modeler is very easy for students to learn to use and produces nice concept maps. Concept maps could also be developed for just the environmental factors and the social factors first, and then these could be merged into one concept map. Using Mental Modeler is one potential way to upgrade this case study to



challenge upper level students.

Figure 1b: Example of a socioenvironmental model developed by undergraduate students about coastal flooding.



Developing the concept map will likely take approximately 15-20 minutes in groups. Next, the instructor should have the whole class come back together and have one group volunteer to put their environmental science concept map up and explain it. The students should articulate why they put a positive, negative or mixed arrow on each relationship. Then the instructor can ask the other environmental science groups if they developed concept maps that were different. The instructor can then walk through some of those differences as a class and ask the students why there are these differences. This discussion probably will take 10-20 minutes depending on how many groups the instructor calls on to walk through their concept map.

Next the instructor can have a social science group put up their concept map and walk through it. Again, the instructor can have other groups comment on differences in their concept maps, explaining the relationships as they saw them. (This can again take 10-20 minutes depending on how many groups present.)

Formative Assessment: In addition to observing the group process and dynamics, instructors can finish with assigning the students a 1-minute paper in which they are asked to write out their thoughts on why concept maps are different and what they learned from the exercise.

Part III: The instructor begins by briefly discussing what a socio-environmental system is (ideally having had the students read some background material on this as homework so instructors can ask students to describe what they are). The instructor asks the students if they can provide examples of socio-environmental systems. The next step is to create "synthesis" groups that include at least one social scientists and one environmental scientist. The instructor asks the students to work through developing a socio-environmental synthesis concept model by combining their environmental and social science concept maps. This activity will likely take 25-30 minutes. Instructor should walk around and make sure group dynamics are going well.

At the end of the group work time, the instructor can ask a few groups to write up their models on the board and then walk the class through how they joined the two systems. The instructor can prompt discussion with questions such as, "What connections did the students see?" Once a few groups have presented, it should become clear that there are differences between the models. The instructor can ask the students why there are differences, if there is there a "correct" concept map, and if not, explain why not? The instructor can help the students understand that there is not one "right" concept map but that concept maps depend on context, stakeholders, and their perspectives. In this case, the concept map may depend on what type of scientists are working in the system, the type of study and data collection needs. (See Figure 1 for an example concept map).

Formative Assessment: The instructor can have the students reflect of the case activities in a journal entry as homework on what they learned about socio-environmental systems and concept mapping.

Activity 1: Additional Thoughts on Conceptual Mapping After Having Taught it Once:
We had Dr. Cynthia Wei give an intro to socioenvironmental synthesis and systems. It took about 75 mins. If you as an instructor need to give an overview of socioenviroinmental synthesis and concept maps yourself, there is a resource available at SESYNC website: http://www.sesync.org/tutorial-1-overview-of-socio-environmental-synthesis

Then we did the case study which also seemed to go well. We did a group brainstorm for about 10 mins and then had the students start binning their ideas into bigger categories on the board. Then we broke into the env or social group and students took about 20 mins to work on those systems. We did a brief report out. Then we jigsawed and the students developed a socioenvironmental system. We gave them about 20 mins. It felt as if they could have used more time (another 5-10 mins) and then the report outs also felt a bit rushed. We also would have

liked to have time to do a brief 1 min paper or some kind of feedback on what they thought of the case study, but we ran out of time.

Notes on concept mapping: Students had difficulty with putting arrows on the concept map because direction and + or - was hard to determine. For example, does a + mean that the arrow is a "good" thing or that something is increasing? The students found it hard to be consistent between different relationships because sometimes it was obvious about which way an arrow should point and whether it was positive or negative. But, for example, does the economy have a positive arrow with built infrastructure? If you have the money to invest in built infrastructure then this could have a positive impact on the economy increasing GDP. But the cost of building the infrastructure could be seen as a negative economic impact on a community. So, the students really discussed but also struggled with which arrows to include and with direction, and then particular how to put plusses and minuses on the arrows.

As another example in the intro that Cindy gave, she had nitrogen in her figure of coastal ecosystems and eutrophication, but then discussed should the arrow between N and productivity be a plus because increased N increases productivity, or it is a negative because we know that is what leads to dead eutrophication impacts like dead zones. The first way is fact-based whereas the second way is impact/value-based (with a human focus on what is desirable for humans and a judgment of what impacts are desirable). You don't want to mix these two in one concept map. You probably want to pick to do one of these and justify why you have picked the fact based or value based method (i.e., are you doing a scientific assessment of changes in an ecosystem? or are you putting together a policy support diagram where you want to lay out the human values in a system?). Having tried this concept mapping activity in class once now, if we do it again, we would have a discussion with the students about the different approaches and likely ask them to do a short in class exercise with a provided two copies of the same concept map of eutrophication and then ask them to put the arrows and plus and minus signs on first from a science-based assessment and then using a value-based assessment to be able to compare the differences.

Ahead of time we assigned the following reading for the students:

Palmer, Margaret A. "Socioenvironmental sustainability and actionable science." BioScience 62.1 (2012): 5-6.

And we asked the students to respond in their reading journals to the following questions:

1. What is socienvironmental science? Why does Dr. Palmer think it is important? What is actionable science?

For Instructors, the following reading may also be useful:

Proctor, James D., and Jennifer Bernstein. "Environmental connections and concept mapping: implementing a new learning technology at Lewis & Clark College." Journal of Environmental Studies and Sciences 3.1 (2013): 30-41.

Activity Two: Negotiation

This activity is meant to give students an introduction to the negotiation process and the key underlying concepts. This activity could be used as part of a class on negotiation in which case a student could be assigned to facilitate the negotiation. However, if this is the first time you are using negotiation in your class, we recommend the instructor facilitate the discussion. This may mean using a few class periods to run different rounds of negotiation or recruiting grad students or other faculty to help facilitate the groups simultaneously, depending on how many students are in the class and therefore how many groups you have.

Break students in groups of ~6 students so that each student gets a "role." Prior to negotiations, each student/stakeholder should read the student handout and the negotiation prompt (which is the letter of Memorandum provided in the student handout file). The negotiation prompt describes a specific task, such as developing a flood management plan to be adopted by City Council of Miami Beach, and gives the setting in which the negotiation in the class will occur.

Prior to the negotiation each student should investigate their stakeholder's perspective on flooding issues in Miami Beach. The students should determine the following for their stakeholder: (1) key values/objectives in the negotiation; (2) central interests/favored policy alternatives; (3) beliefs about scientific uncertainty; (4) any scientific information or data that has been produced by the stakeholder. The students should be given at least a week or so to investigate prior to the negotiation.

It is very important that the students prepare for the negotiation by learning about their assigned role. The reading journal questions below help students to do that as well as the suggested readings. We also suggest that answers to these questions be reviewed by the instructor ahead of class to help any students who may be having difficulty figuring out what their role and their talking points might be during the negotiation.

As far as time management goes for this negotiation, if you have 75 mins classes, here is a suggestion for how to run your class.

Once students arrive at the negotiation class session (3 class periods, 75 minutes each), the students should convene in stakeholder groups for approximately 20 minutes (e.g., all tourism boards meet together). In these meetings, the student/stakeholders should review their values, interests, beliefs about scientific uncertainty, and discuss a negotiation strategy. Once these meetings within each stakeholder group end, the students should begin negotiation in their groups of mixed five-six stakeholders, where each student represents the perspective from the stakeholder group they represent (i.e. tourism, engineer, etc.).

In the first negotiation session (approximately 30 minutes), the stakeholders should (1) introduce themselves, (2) develop negotiation guidelines, (3) nominate a note-taker and (4) review the negotiation task prompt. In the next class session (75 minutes), negotiations should begin. At the end of 50 minutes, each group should record the agreement that is reached into a PowerPoint slide. With the remainder of the class period, students will present their negotiated agreement to the class (3-5 minutes each). In the third (last) class session of this case study role play, the instructor should lead a discussion on the general themes of the role play, drawing on the readings for the course.

Instructional Note: We realized after doing this activity that the students knew nothing about the Miami Beach area. So, if we taught this again we would ask the students as part of their preparation to look at google maps satellite view and become familiar with the Miami Beach area, where the major built infrastructure was located, and where there were existing natural areas including beaches, dunes, and coastal wetlands.

We received feedback that this activity was one of the most valuable we did during our semester, so this can be a very useful activity for students.

Reading Journal Questions to Prepare Students before the Negotiation: In class on XX date we will be doing a conflict resolution activity. In preparation for this negotiation, you should complete the readings and answer the following reading journal questions. The readings include information on the negotiation assignment (the Miami Beach Flooding Intro, student handout you read earlier this semester for week 2 and then in addition there is the "Miami Beach Negotiation Student Info" sheet) and a reading on negotiation basics (MIT website listed below). Read all 3 carefully.

In addition, you need to understand the difference between an "interest" and a "position" since you need to develop a position. To help you with that distinction, please look at the following MIT website: http://web.mit.edu/negotiation/www/NBivsp.html

Finally, also look at google maps satellite view and familiarize yourself with the area, including the major built infrastructure features such as bridges, roads, major developments and housing, as well as existing natural areas such as beaches, dunes, and wetlands.

You will be responsible for presenting the interest of a specific stakeholder. As you answer the following questions, it would be useful to think of your answers as talking points that you will use during class to represent your stakeholder's interests. These talking points should clearly and succinctly articulate your interests regarding flood management and your thoughts on the state of the science in understanding the cause and extent of flooding in Miami Beach. Please bring to class a printed out version of your answers to the nine questions below to help you in the negotiation.

1. Write a short paragraph describing the stakeholder you have as your role for the negotiation. Who is this person?
2. Specify your stakeholder's key objectives, interests and favored management options regarding flood management in Miami Beach.
3. Describe your stakeholder's beliefs about the science of flooding, including causes, severity and future predictions of flooding.
4. List any scientific data or analysis that has been collected or produced by the stakeholder on flooding in Miami Beach (or elsewhere).
5. Based on looking at the MIT website, you need to develop an interest statement for your stakeholder in the negotiation. Here is an example of a position versus an interest:
    a. Example: Interest: We should design a flood management plan to maximize economic development. Position: I oppose the construction of a seawall in Miami Beach. To get from position to interest, students should ask themselves why (e.g.,

Why do you oppose a seawall?) Please provide a statement of your interest that is line with the role you are playing in the negotiation.

6. Based on reading the chef example with the orange, why do you think it is important to understand interests versus a position? How can understanding interests be useful or helpful in a negotiation?
7. How does the idea of interests (vs positions) relate to the "Solution Possibility Frontier" discussed in the "Negotiation and Collaborative Problem Solving" reading? What do you need in order to collaborate in finding a collaborative negotiated solution?
8. What is a BATNA? Describe what you think your stakeholder's BATNA is (think about trade-offs, alternative solutions, etc). This helps to frame your negotiation so you know when it is better to keep working toward a negotiated solution and when you should stop and go with your BATNA.
9. It can be useful to focus on everyone's interests in order to find a collaborative solution. After reading the Principled Negotiation section of the reading, think about one of the other stakeholders who will be present. Describe what common interests you think you have with that stakeholder that might help you in the negotiation.

Suggested Additional Class Readings on Conflict Resolution

Key negotiation concepts

Fisher, R., W. Ury, and B. Patton. (2011), *Getting to Yes, Revised Edition*. New York: Penguin Books.

Cognitive biases in negotiation

Caputo, A. (2013). A literature review of cognitive biases in negotiation processes. *International Journal of Conflict Management*, 24(4): 374-398.

Thompson, L., Nadler, J. and Lount, R.B. (2006), Judgmental biases in conflict resolution and how to overcome them, in Deutsch, M. and Coleman, P.T. (Eds), *The Handbook of Conflict Resolution: Theory and Practice, 2nd ed*., Jossey-Bass, San Francisco, CA, pp. 213-235.

Integrative solutions in negotiations

Caputo, A. (2012), "Integrative agreements in multilateral negotiations: the case of Fiat and Chrysler", International Journal of Business and Social Sciences, 3(12): 167-180.

Pruitt, D.G. and Lewis, S.A. (1975), Development of integrative solutions in bilateral negotiation, *Journal of Personality and Social Psychology*, 31: 621-633.

Activity Three: Group Decisional Memo

This assignment is the capstone activity in our case study which pulls together all the previous work into a final assignment. In our class students were introduced to many topics related to coastal resilience including indicators, natural and hybrid infrastructure for storm protection, and coastal stressors and impacts on ecosystem services. If you would like to assign some additional

readings to your students on any of these topics, please see the reading list in Section 9c with suggestions.

This last activity asks the students to work as a group of experts who have been assigned the task of developing recommendations for the city of Miami Beach on what flood reduction techniques the city should implement. All stakeholder perspectives must be addressed in the development of the decisional recommendation, but it is fair to point out to students that compromise of some kind is likely going to be needed. The students need to justify why they are making the recommendation(s) they are.

Readings Journal Questions to Prepare Students for Activity 3 Decisional Memo (these could be used to help with the negotiation activity as well to help familiarize students with the Miami Beach area): Using google maps, explore the area of Miami Beach, FL south of Rte 112 and the Julia Tuttle Causeway.

- What natural or green infrastructure already exists in this area?
- What are the major gray/built infrastructure features the community may want to protect in particular?
- What parts of the community seem most vulnerable to extreme events and storm surge?
- Do you see any features in the landscape that appear to be managed open space or green space that might be able to serve as flood protection?

8. Background Information for the Instructor for the Case Study[2]
(The instructor can decide whether any of this additional information should be provided to the students in a handout or whether some of the citations would make good class reading assignments.)

Sea Level Rise
In a study of port cities worldwide, the Miami region was ranked number four for exposure to sea level rise in terms of population and number one in terms of assets (Nicholls et al. 2008), due to its large population at low elevation. Though there is significant uncertainty about the timing and rate of sea level rise, the International Panel on Climate Change (2007) stated sea level could rise by up to 1.4 meters (IPCC 2007) due to rising global temperatures, even if greenhouse gas (GHG) emissions begin declining (See Figure 2). The rate of relative sea level rise varies for coastal areas, and South Florida is experiencing a moderate rate of 2mm per year with minimal subsidence. South Florida has already experienced about 6 inches of sea level rise over the last century. The Southeast Florida Regional Climate Compact developed projections for sea level rise to be used by planners and governments in South Florida. The projections are for 9 to 24 inches of sea level rise by 2060.

[2] Adapted from Eisenhauer, E. 2014. Socio-ecological vulnerability to climate change in South Florida. In *Comparative Sociology*. Miami, FL: FIU Electronic Theses and Dissertations.

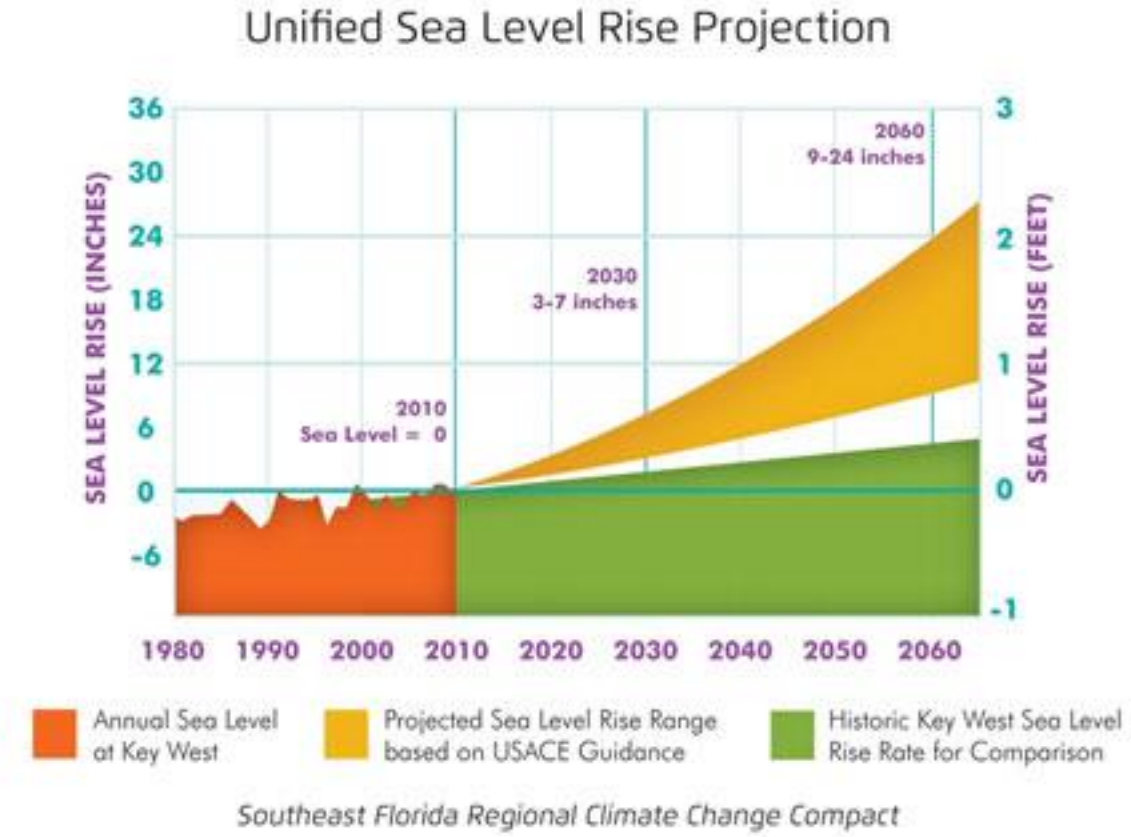


Figure 2: Sea Level Rise Predictions for Southeast Florida. *Source: Southeast Florida Regional Climate Compact. http://www.fortlauderdale.gov/gyr/climate_resiliency/sea_level_rise.html*

Storms

Climate change and sea level rise also mean potentially more destructive hurricanes, due to higher storm surge levels and potentially more intense storms driven by warmer ocean water. Warming oceans mean that hurricanes may become stronger, with "the number of category 4 or 5 storms forming in the Atlantic basin roughly doubling after 80 years of greenhouse warming," although the number of overall Atlantic storms may decrease by twenty-eight percent by one prediction (Misra et al. 2011). Stronger storms cause exponentially more damage, and "an 11% increase in wind speed translates to roughly a 60% increase in damage" (Borenstein 2010). Recent research has concluded that the relationship between sea level rise and storm surge is non-linear, and that extreme tidal events will occur more frequently (Obeysekera and Park 2013).

Coastal Ecosystems

Most of Miami Beach was originally covered with mangrove forest, with narrow sandy beaches on the ocean side. As the island was developed the swampy land on the western side of the island was bulkheaded and filled with material dredged from the bottom of Biscayne Bay. Almost a dozen man-made islands were also created with dredged material. In the 1970's the Army Corps of Engineers created a dune system and a wide sandy beach, and periodic beach renourishment has brought in sand lost to erosion or relocated sand that gradually washed from one place to

another. The beach and the dunes serve to protect the island from hurricane storm surge, and are an important sea turtle nesting habitat. The City recently began partnering with non-profit organizations on restoration of the dune system, which will remove invasive plant species and restore native vegetation, reducing erosion and improving the habitat.

There are few other examples of green infrastructure although there are promising discussions about conducting a tree census and a natural capital analysis of the capacity of trees to improve water absorption.

The City discharges storm water to Biscayne Bay and must maintain water quality standards under a state permit.

Built Environment

A Vulnerability Analysis performed by the Southeast Florida Regional Climate Change Compact (SFRCCC), an agreement among the four counties in the region to cooperate on climate change policy and planning, found that one foot of rise would affect 80,000 acres and $4 billion of taxable property value across the region[3], including two airports, three power plants, and three hospitals. A recent regional planning effort that included sea level rise scenarios recommended a variety of strategies including retreat from some areas and fortifying coastline in others both with natural buffers such as mangroves and sand dunes, and with engineered solutions such as water controls structures, sea walls, levees, and elevating infrastructure (Southeast Florida Regional Partnership 2013). As a reaction to the flooding problems the City of Miami Beach has taken the step of improving storm water management, and has received attention for being the first municipality in the region to include sea level rise projections into infrastructure planning when it proposed a new storm water management master plan (SWMMP) in 2009. The plan calls for installation of dozens of new pumping stations and backflow preventers, and raising sea wall heights to 3 feet from currently 1-2 feet. It will cost approximately $400 million and the storm water utility fees will go up by approximately $7 per month per household (Veiga 2014).

Economy

South Florida's environment has always been intertwined with its economy. Agriculture, tourism, and real estate are three major climate-dependent sectors of the economy. Development began on Miami Beach in the early part of the 20th century after early attempts at agriculture provide difficult to maintain. Miami and Miami Beach benefitted from the 1920's boom time all over the nation when the wealthiest Americans came to spend the winter in Miami Beach. Developers financed and built infrastructure such as bridges for cars, canals, and donated land to the city for parks and schools. Despite the interruption of a devastating hurricane in 1926, development rebounded and continued through the 1930's, 40's and 50's. During the 1970's Miami Beach entered a slump, and became known for large numbers of elderly residents and a high crime rate. In the 1980's renewed interest in preserving the historic Art Deco buildings of the 1920's and 1930's led to the revival of the area's tourism economy based on arts and entertainment, and of course climate (Kleinberg 1994).

[3] Southeast Florida Regional Climate Change Compact (SFRCCC). 2012. Analysis of the Vulnerability to Southeast Florida to Sea level Rise. http://southeastfloridaclimatecompact.org/compact-documents/.

Miami Beach is a major tourism destination; in 2010 it had a Gross City Product of almost $7 billion annually, five million overnight visitors and seventeen million beachgoers annually. About a quarter of Miami Beach's economy is hospitality, and forty-four percent of the jobs in the city are in accommodation and food services. Approximately 30,000 people commute to Miami Beach daily for work, increasing the City's daily population by one-third. Cost of living is high on Miami Beach. While there are many multi-million dollar homes and condominiums, there are also many who live in small rented apartments in relatively poor condition. Rent prices have risen dramatically in Miami Beach in the last decade, from $632 per month in 2000 to $1059 in 2012 according to the U.S. Census -- an increase of sixty-seven percent compared with sixty-three percent in Miami-Dade County as a whole and forty-seven percent in the U.S. The fact that the median rent in the County is nearly as high as Miami Beach, at $1057 in 2012, means that there is little refuge for those who can ill afford the rising rents on Miami Beach.

Government

Located at the southern tip of Florida, Miami is the core city of the southeast Florida region, a region of 5.5 million people that stretches 250 miles from Key West to Palm Beach. The region encompasses 112 municipalities in four counties, which are connected economically and through transportation but have recognizable cultural differences and separate identities within the South Florida identity. In 2009 four southeastern counties – Monroe, Miami-Dade, Broward, and Palm Beach – agreed to form the Southeast Regional Climate Change Compact in order to collaboration on assessment and planning for climate change. A regional summit has been held every year since, and in 2012 the Compact released a Regional Climate Action Plan with over 100 recommendations in areas such as infrastructure, transportation, energy, natural resources, and public education. Miami Beach is the municipal representative to the Compact for Miami-Dade County, and has signed the Mayor's Climate Action Pledge. Miami Beach utilizes some services provided by Miami-Dade County including water and sewer and transit, but manages its own storm water, waste and recycling, and police department.

Community

Miami Beach is known as a wealthy area but also has many residents who would be considered vulnerable according to traditional indicators of age, race, income and gender. The City has a large population of elderly residents, many of whom live in single-person households, and are significantly more likely to live in poverty than their U.S. peers. Many of the city's lesser well off residents work in low-paying jobs in the city's many hotels and restaurants. According to data from the U.S. Census Bureau, over half the city's residents are foreign-born, most from Latin America, but there are also significant numbers from Europe, Russia, and Canada. Three-quarters speak a language other than English at home, and forty percent speak English "less than very well." Miami Beach also reflects the transient character of the larger Miami metro area. More Miami Beach residents lived somewhere else in the U.S. or abroad in the past year than did in the U.S. as a whole. Miami Beach has a gap between socioeconomic groups reflected in the skewed income distribution. The median household income is $42,330, lower than the U.S. median of $51,222, however the mean household income is higher than the U.S. mean by about $8,000. High rents and property values and a recent come back in the housing market reflect the high desirability of the City as a place to live and the influx of investor owners particularly from Latin America. A majority of residents, sixty percent, are renters, and half of renters pay more than thirty-five percent of their income in housing costs. The urban character of the city is

reflected in transportation options--a quarter of households don't have a car, and higher percentages walk or bike to work than the national averages.

Culture

Miami Beach has a significant collection of historic buildings in three architectural styles – Art Deco, Mediterranean Revival, and Miami Modernism. Many of these are on the National Register of Historic Buildings and are protected by local ordinances that set out strict rules and design guidelines for rehabilitation and new construction to preserve continuity in the urban area. The protection of these buildings and the historic district was achieved through a grassroots organizing effort starting in the late 1970's which gradually convinced city officials and the public of the value of the buildings and attracted investment for rehabilitation and renovation. The movement catalyzed the revival of the city and its economy, and continues to have a strong influence on local politics.

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9b. Recommended Further Reading

Possible advance readings for the students or faculty

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10. Assessment

For Activity 1, formative assessment as students do the exercise is key. But summative assessment afterwards makes sense to do on a homework assignment or exam where students would be asked to do another concept map in a different system or a different geographical region. Students would be asked to draw the concept map and justify and explain the pieces of the model and the relationships between the pieces. In grading, instructors should look for the following:

1. Did the student forget to include any major parts of the system?
2. Are the arrows connecting the boxes correct (meaning do they have reasonable justifications for the connections and arrow directions between the different boxes)?

3. Are the explanations for what was included in the conceptual model adequate?

Example Discussion and/or Assessment Questions

- What factors affect flooding?
- Who is affected by flooding?
- What do floods affect?
- Why are there differences between the conceptual models produced by the different groups?
- Is there a "correct" concept map? Why or Why not?
- What other boxes do you think should be included in the conceptual model?
- What relationships between the boxes or arrows were difficult to determine (either the linkage or the direction)?
- What additional information did you want that you didn't have?
- If a decision-maker were to make a decision about flood management, what stakeholder perspectives would need to be included in these decisions?
- Are all of these perspectives represented in the socio-environmental conceptual model?

For Activities 2/3, the assessment is predominantly summative with Activity 3 (decisional memo/report) being the capstone project that demonstrates the students' ability to master and demonstrate socio-environmental concepts and synthesis in a specific situation.

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