

## ***RESILIENCE TO CLIMATE CHANGE: A SOCIO-ECOLOGICAL CASE STUDY FROM PUERTO RICO***

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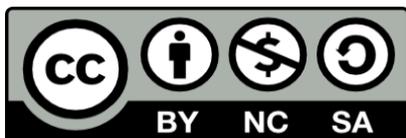
**Author's Note:** Please contact the authors if you have questions or would like to tell us about your experience with this case study.

### **Summary**

As a result of climate change, both cyclonic storms (e.g., hurricanes) and droughts are increasing in severity and frequency around the globe. Additionally, sea level is rising. This poses a particular challenge for island communities. This case study looks at Puerto Rico, a U.S. territory located in the Caribbean. Puerto Rico was struck by two hurricanes (Irma and María) in the span of two weeks in September 2017. In addition to the environmental pressures of climate change, the island has also experienced social and political upheaval, resulting in a twofold challenge to community resilience. This socio-environmental synthesis case study integrates historical, governance, biophysical, and socio-economic analyses of Puerto Rico to consider the role of community resilience as a strategy for climate adaptation. It focuses on the eastern region of the island surrounding El Yunque National Forest, illustrated through the story of La Vega community. This case study is appropriate to lower and middle levels of undergraduate education and takes place over three class days, with assignments preceding each class day.

**Keywords:** Climate change, resilience, Puerto Rico, decolonialism, Hurricane María, El Yunque National Forest

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### **What course(s) is this case appropriate for?**

This case study is appropriate for science and non-science majors, including subjects like climate change, environmental planning, environmental policy and management, environmental studies. Students are expected to have prior basic knowledge of socio-environmental (S-E) systems and resilience theory.

### **What level is this case appropriate for?**

The case is appropriate for lower and middle undergraduate levels. The case works well in a class of up to 20 students, or, through the use of small groups, it could work in a larger lecture setting.

**S-E Synthesis Learning Goals** - this case study addresses the following S-E synthesis goals:

- **Goal 1:** Understand that ecological and social processes often vary across differing contexts, including space and conditions (e.g., economic or political).
- **Goal 2:** Integrate different types of data.
- **Goal 3:** Understand the structure and behavior of socio-environmental systems.

**Learning objectives:**

*By the end of this case study, students should be able to:*

- Identify and discuss temporal and organizational relationships between elements of a system
- Outline and map different elements, drivers, actors and interactions of a S-E system (SES)
- Identify points of intervention in a system that could increase its resilience to climate change
- Name key events in Puerto Rico history and discuss governmental, biophysical, and socio-economic characteristics of the eastern region of Puerto Rico

**Introduction/Background:**

Puerto Rico is an archipelago in the eastern Caribbean that has experienced intense socio-environmental change in recent years due to economic and political crises, as well as the impact of hurricanes. This case study examines key elements and relationships of the S-E system of Puerto Rico that influence community-level resilience to this change, with a focus on the eastern region of the island. The case study is divided into three units, each one designed to fill one teaching class of 1 h 15 min. The first class includes an overview of the socio-environmental system of eastern Puerto Rico and a timeline activity. The second class introduces the case study, zooming in on the communities that surround El Yunque National Forest (El Yunque), and it includes a concept mapping activity. The third class focuses on community-scale resilience to climate change and includes group discussion and ignite presentations. The case has not yet been classroom-tested; all the times are estimates.

**Classroom Management:**

This case study follows dilemma/decision design with an element of analysis case. The activities include developing a timeline and concept map in small groups, ignite presentations, and full class discussions in class and via Online Discussion Board.

**Total Estimated Time:** Three 1 h 15 min class periods. Total 3 h 45 min in class. Students are asked to do reading and preparation preceding each class, totaling about 2 h 15 min hours out of class work over the 3 days.

**Unit 1. Temporal scale** (1 h 15 min class period).

Activity: Timeline

**S-E Goal 1:** Understand that ecological and social processes often vary across differing contexts, including space and conditions (e.g., economic or political). During the timeline activity, students will use several narratives to select biophysical and human history events to conceptualize current events through a deep history frame.

Before class:

1. Students should watch “The Battle For Paradise” on YouTube (<https://www.youtube.com/watch?v=pTiZtYaB3Zo> (~ 18 min). The video summarizes the impact of Hurricane María and community-scale actions to build resilience.
2. Students should read all 6 narratives (in the student packet): history, governance, biophysical and socio-economic subsystems, as well as the narratives about resilience and the community of La Vega.

In class:

1. Class introductions (if applicable)
2. Overview of the case study, objectives, readings
3. Short lecture (15 min). Google Slides [presentation](#)<sup>1</sup> providing images and limited text to support the descriptive narratives in the student handout.
  - a. Context/background about Puerto Rico and El Yunque as described using 4 sub-systems (history, governance, biophysical, and socio-economic characteristics)
  - b. Intro to La Vega and El Yunque communities
  - c. Systems/resilience theory: What is resilience? How is it defined in the context of this class?
  - d. Discussion of the movie and readings with guiding questions
    - i. There are communities within the U.S. that have incredible challenges in terms of economics and climate change (factors outside of their control at different systems scales). They are self-organizing in response to S-E events across time and the ongoing effects of those events.
4. Small Group Timeline activity (the pre-class readings and the narratives inform the elements that go on the timeline). (20 min)

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<sup>1</sup> Each slide includes references for images used. The presentation can be downloaded and edited as needed. The slides are designed to accompany the content of the narratives in the student packet, and can be used as starting points to build a more comprehensive lecture, if desired. The presentation can be accessed at: <https://docs.google.com/presentation/d/1Ggn7rnBfE1XRzm7GI3hFGek1P5T9gCkDuG5VA68HUZs/edit?usp=sharing>

- a. Supplies needed- 4 colors of markers and a blank sheet of paper for each small group.
  - b. Break the class up into groups of 3-5 students.
  - c. First step: ask students to brainstorm a list of key elements in the narratives at various points of time (for example, Hurricane María hitting the island in Sept 2017).
  - d. Second step: once they have some ideas written on scrap paper, write them on the blank sheet of paper to create a timeline. Tell students to use a different color marker to color code the events corresponding to the 4 different subsystems (history, governance, biophysical, and socio-economic).
5. Return to Large Group to discuss Timelines. (20 min)
- a. Draw a line on the board and ask students to share what they put on their timeline. Create a timeline on the board that merges all events from all the groups.
  - b. Discussion question- ask students about the first and last items on the timeline- when should history start? When does it end? Are there any overarching themes to this temporal depiction of the SES?
6. Homework introduction to the students (Online Discussion Board) -- set rules of participation & assessment). Driving questions clarify the point of the timeline (which is drivers of change across scales):
- a. What elements of this timeline are drivers of SES change? Why?
  - b. How do the 4 subsystems (history, governance, biophysical, and socio-economic) of the SES vary across temporal scales?
  - c. How do elements within the 4 subsystems connect?

***Unit 2. Conceptual relationships with S-E systems*** (1 h 15 min class period).

Activity: Concept map

**Goal 2:** Integrate different types of data. Students will draw from the interdisciplinary narratives to develop concept maps and identify intervention points.

Before class:

1. Readings on concept maps
  - a. SESYNC Tutorial 1: Overview of Socio-environmental Synthesis (Appendix -- What is a Concept Map?)
    - i. [https://www.sesync.org/sites/default/files/2023-07/Tutorial overview of socio-environmental synthesis.pdf](https://www.sesync.org/sites/default/files/2023-07/Tutorial%20overview%20of%20socio-environmental%20synthesis.pdf)
  - b. Developing Concept Maps
    - i. <https://serc.carleton.edu/introgeo/assessment/conceptmaps.html>

In class (1h15min class period)

1. Respond to the online discussion board in full class setting (5 min).
  - a. A good way to do this is to share a handful of student comments and respond to them.

2. Introduction to concept mapping (10 min) -- includes nested elements (subsystems, nodes, connectors, feedback, evidence for connections)
  - a. (optional) See accompanying slide on concept maps in the Google slides presentation
  - b. Present students with the following focal question: What is the socio-environmental (S-E) system of La Vega, Río Grande?
    - i. Break students into groups of 3 or 4 and provide each group a sheet of 8.5 x 11 inch notebook paper, a large sheet of poster paper, markers, and multiple sticky notes of four different colors. Ask each group to carry out the following activities (30 min):
      1. On the notebook paper, write at least 10 concepts/elements pertaining to the S-E system.
        - a. Students should draw on content presented in the supporting narratives and background reading.
        - b. Each concept/element should contain only one or two words.
        - c. Concepts and components may or may not be scientifically accurate -- there are many ways to organize and represent knowledge of the system and there is no correct answer.
      2. Classify each concept/element as pertaining to one of the four dominant S-E subsystems:
        - a. History
        - b. Governance
        - c. Biophysical
        - d. Socio-economic

Write the concepts/elements pertaining to each subsystem on sticky notes of different colors.
      3. On the poster paper, write the title "The S-E System of La Vega at the top of the page.
      4. Place the sticky notes representing concepts/elements from all of the subsystems on the poster paper. Place the notes in a hierarchical fashion with the "most general and inclusive" or "most important" items at the top of the paper, and the "least general and inclusive" or "least important" items toward the bottom. Include as many levels of hierarchy as personally meaningful.
      5. Connect concepts/elements, one pair at a time, with directional arrows between discrete sticky notes. Label the connecting lines with a descriptive verb or phrase (e.g., Carrots → vitamin A (linking word is, "contain") OR meat → iron (linking words are, "is a good source of"). Focus on connecting both within and across subsystem categories.

6. Add additional concepts/elements, linkages, as desired. Continue the connection process until all concepts/elements are linked at least once.
7. Neatness doesn't count -- students may re-draw maps as often as they wish.
8. Have each group select a representative to present their concept map to the class (30 min).
  - a. Using the sticky notes from each group, create a mega-concept map on the blackboard or whiteboard that captures the input from all groups
  - b. Focus attention on differences in the placement of concepts/elements and connections among groups. Attempt to arrive at consensus where there are points of disagreement
9. Wrap-up & explain Online Discussion activity (5 min)

**Unit 3: Linking to local, community scale resilience.** Points of intervention. Where are the points of interventions to make the community more resilient?

Activity: Group Discussion and 5-min ignite presentation

- **Goal 3:** Understand the structure and behavior of socio-environmental systems. Students will apply resilience theory to the socio-environmental system to assess community resilience efforts.

Before class:

Online Discussion Forum -- (same rules of participation & assessment). Have students respond to each of the following prompts/questions:

- a. Describe the relative strength of linkages among map elements (pick 3)
- b. Describe any feedbacks that might exist among map elements, and whether they are positive or negative.
- c. What is the evidence for the connections and feedbacks among concept map elements (e.g., scientific data, news articles, personal experience, beliefs, etc.)?
- d. Describe any elements and connections might be missing from the concept map, or how the map could be reorganized.

In class:

- a. Brief discussion into resilience theory
- b. Activity: small-group discussion on community resilience
  - c. Show together the timeline and the concept map. Objective is to integrate social and environmental factors to identify leverage points and create just climate resilience (using La Vega as focal point).

- d. Discussion questions (in small groups):
  - i. Knowing the temporal and organizational system components, what other elements/events drive climate resilience of the community?
  - ii. Where (and how) in the system would you intervene to augment resilience to disruptions to transportation/light/water infrastructure?
  - iii. Where else in the system could you find other examples/interventions to increase resilience?
  - iv. Write down two columns: grassroots community organizing and federal government (U.S). Consider climate resilience responses that could happen at these two different governance scales. Compare and contrast. Which ones seem most promising?
  - v. Use the concept map and timeline to explain the relationship between colonialism and the post-María crisis in Puerto Rico.
  - vi. What information is missing? What more would you like to know?
- c. With full class
  - e. 5-min presentation summarizing small-group discussions
  - f. Wrap-up

### **Learning Objectives and Assessment Techniques:**

- Identify and discuss temporal and organizational scale relationships between elements of a system
  - The online discussion forum based on the timeline activity can be used to assess how students meet this learning objective.
  - Students should be able to discuss the elements of the timeline (temporal) and relate them to the 4 subsystems. They should be able to explain how the elements vary across scales of social organization.
- Outline and map different elements, drivers, actors and interactions of a S-E system
  - The online discussion forum based on the concept map activity can be used to assess how the students meet this learning objective.
  - Students should be able to give knowledgeable answers to the discussion questions. Specifically the references to feedbacks, elements, and strength of linkages relate to the elements, drivers, actors, and interactions of the S-E system.
- Identify points of intervention in a system that could increase its resilience to climate change
  - The small group discussion on community resilience can be used to assess how the students meet this learning objective.
  - When the students give the 5 minute presentations, they should be able to apply the concept of community resilience to the case study and provide suggestions as to how community resilience can increase as the result of specific interventions.
- Name key events in Puerto Rico history and discuss governmental, biophysical, and socio-economic characteristics of the eastern region of Puerto Rico.
  - The timeline activity can be used to assess how the students meet this learning objective.
  - In particular, students should be able to choose at least 8 events, with at least one event from each of the 4 subsystems. They should be able to say why they thought

the events were important and be able to say which subsystem is represented by each event. This will show an ability to synthesize the 4 subsystems into a single socio-environmental synthesis.

### **Suggested supplemental readings:**

- García Polanco, V., & Rodríguez-Cruz, L. A. (2019). Decolonizing the Caribbean diet: Two perspectives on possibilities and challenges. *Journal of Agriculture, Food Systems, and Community Development*. Advance online publication. <https://doi.org/10.5304/jafscd.2019.09B.004> A concise, engaging reflection on the Taino identity, food, and agriculture
- **Encyclopedia of Puerto Rico:** <https://enciclopediapr.org/en/>  
Students could peruse through this online resource for general information about Puerto Rico, brief history, and photographs of municipalities that comprise the case study region.
- **Puerto Rico Syllabus:** <https://puertoricosyllabus.com/>  
Compiled resources on the Puerto Rico debt crisis and Hurricane María.
- **El Yunque National Forest Atlas:** <https://www.fs.usda.gov/treearch/pubs/56095>  
The document summarizes current ecological, socioeconomic, and cultural conditions of the national forest and surrounding landscape of eastern Puerto Rico.

### **Suggested Modifications**

Omitting concept mapping readings and introduction is possible if the students are already familiar with concept mapping. The case study could be expanded by selecting another community affected by climate change (either in Puerto Rico or in the USA) and comparing their vulnerability and resilience to climate change to that of La Vega community.

### **References**

References are provided in the student handout.

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