SESYNC Case Study: Hydraulic Fracturing in Michigan
Teaching notes

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Summary
This case study exposes students to a socio-environmental (S-E) framework to examine complex systems, using hydraulic fracturing (HF) in Michigan as an example. This framework will allow students, especially those in the social sciences, to examine other complex socio-environmental systems. This case study applies an interrupted case approach to explore the relationships between state level policymaking, environmental science, public discourse, media coverage, and risk perceptions. Michigan has a long history of HF, but new technical developments, as well as a push for energy independence at the state level, and controversies in other states over the technology (e.g. New York and Pennsylvania), have raised public concerns in the state. The case study was designed for students in environmental studies, communication, public policy, among others, specially in the social sciences. It is intended to be an 8-12 week case study.

For what courses might this case study be appropriate?
This case study is designed for implementation as an interrupted case throughout an academic semester (somewhere between 8 to 12 weeks). The case study was originally developed for students in journalism and mass communication, but it could be tailored for students in other fields and disciplines. The module on media content could be scaled down to provide space for the implementation of additional modules or the expansion of the other modules (e.g. science, policy, public opinion). Students will work in most class activities in small groups of 3-5 students, so a maximum of 30 students is recommended to keep the group activities manageable.

For what level of students is this case appropriate?
The case study was designed for upper level undergraduate students and Master's students. The case study could be appropriate for lower level students depending on their background and level of engagement with the topic.

Case study goals
The core goal of this case study is to improve students' learning outcomes related to content knowledge, systemic thinking, and research-based learning through the use of interdisciplinary and collaborative learning teams. This case study is principally designed for students in the social sciences with limited exposure to socio-environmental (S-E) synthesis research or to the natural sciences. Few students in journalism and mass communication come prepared with a science background that allows them to fully understand the ways in which science and science-based issues should be objectively and accurately reported. This case study is designed to better

prepare students in understanding scientific concepts and to improve their critical thinking skills, which can lead to improvements in the quality of their communication skills (e.g. reporting, public engagement).

This case study can serve as a model for the implementation of interdisciplinary learning among disciplinary departments (e.g. communication, political science, geology, hydrology, etc.). This case study seeks to create a mechanism in which students will interact, engage, and collaborate with their peers in other fields.

A summary of the specific learning goals, objectives, activities, and assessments is presented below in Table 1.

Table 1 - Summary of learning goals, objectives, activities, and assessments

SESYNC learning goal	Detail of goal	Learning objectives	Activity	Assessment
Goal 1: Understand the structure and behavior of S-E systems	Identify and explain the various components of the scientific method	Students will be able to explain the basic science behind hydraulic fracturing	Students will analyze a technical and scientific report about hydraulic fracturing. Students will develop a summary of the research report	Formative assessment of a summary of the research report using layman's terms.
Goal 1: Understand structure and behavior of S-E systems Goal 2: Consider importance of scale and context in S-E problems	Develop the ability to understand energy systems. Develop the ability to understand and apply systems thinking. Students will understand how different components of energy systems are related and affect each other	Students' will improve their understanding of energy production, distribution and consumption from a systemic perspective. Students will explain the components of the socio-environmental system surrounding the policy decision-making process about hydraulic fracturing in Michigan.	In class discussion about energy systems in the U.S. Development of conceptual map illustrating the HF system in Michigan	Formative assessment of the conceptual map through the in-class-discussion of each students/groups' work
Goal 2: Consider importance of scale and context in S-E problems	Critically assess scientific and political claims about hydraulic fracturing in MI.	Students will develop and apply critical thinking skills by identifying and evaluating the discourses of the various stakeholders involved in the issue.	Students will write an essay identifying claims and claims makers in a documentary about HF	Summative assessment of the report[1]
Goal 3: Develop research questions and models in inter or trans- disciplinary teams	Learn about the role of the media in a S-E system	Students will apply basic principals of journalism and mass communication research to environmental and science issues	Students will analyze public opinion and media data. Students will conduct and present a content analysis of media	Summative assessment of the media report[2]

[1] See additional document "*Rubric for Assignment 1*"

[2] See additional document "*Rubric for Assignment 2*"

			reports about HF in Michigan.	
Goal 3: Develop research questions and models in inter or trans- disciplinary teams Goal 4: Find, analyze, and synthesize existing data and ideas	Find and analyze S-E data to understand the risks and benefits of hydraulic fracturing in MI	Students will develop competencies in integrating media analysis, policy analysis, scientific evidence, and survey data, among others. Students will synthesize various data sources into a comprehensive narrative.	Students will produce an interdisciplinary website. This project will be developed in stages throughout the duration of the case study and will integrate the results of the previous activities listed above.	Summative assessment of the website.[3]

Classroom Management

This case study is designed with seven sequential modules each lasting about 2.5 hours. The exception is module 6 (media analysis), which is designed to take two sessions of 2.5 hours for courses in journalism and mass communication. This module could be reduced to one session if needed.

Module 1
Introduction to S-E synthesis, systems thinking, and case study

Purpose

a. To introduce the case study and the topic to students
b. To introduce the concept of S-E synthesis research

General description

The instructor will introduce the case study with a brief description of hydraulic fracturing in the U.S. This will be followed by an introduction to the topic in the context of Michigan.

Relevant handouts

Students will read ahead of the class the information about HF in the website of Michigan's Department of Environmental Quality (DEQ) and the University of Michigan report on HF. Students will also read a resource about smart grid in the US. The instructor will base the presentation and discussion on these resources.

- Michigan Department of Environmental Quality: Hydraulic Fracturing in Michigan (http://www.michigan.gov/deq/0,4561,7-135-3311_4111_4231-262172--,00.html)
- Bowman, D., Gosman, S., Lacy, S., Wolske, K., Callewaert, J., Allan, M., ... & Wightman, S. (2015). High Volume Hydraulic Fracturing In Michigan

[3] See additional document "Rubric for Final Project"

Integrated Assessment Final Report (http://graham.umich.edu/media/files/HF-IA-Final-Report.pdf)
- Creating a smarter U.S. electricity grid. From Journalist's Resource (http://journalistsresource.org/studies/government/infrastructure-government/u-s-electricity-smart-grid)
- Ostrom, E. (2009). A General Framework for Analyzing Sustainability of Social-Ecological Systems Science JUL 2009: 419-422

Logistics

a. The instructor will start with a brief introduction to the case study and the issue of HF based on the required readings (45 minutes).
b. Discussion about students' personal perceptions of the issue, asking students to also consider their understandings of the material they read ahead of the class (60 minutes).
c. Students will work in small groups (2-4 students) to develop their own personal mental maps of the different components of the energy system in the U.S. They can also use the information presented in the assigned readings (45 minutes). This maps can later be revisited to compare to new iterations done later during the case study.

Homework assignment: Students will complete the readings on scientific and technical aspects of HF listed below under Module 2. Students will develop 2-4 questions about the readings and post them to the online management system (e.g. Blackboard, D2L). These questions will be used in the next meeting as discussion points.

Module 2
The scientific and technical aspects of HF

Purpose

a. The purpose of this module is to develop competencies in the understanding of basic scientific concepts and processes for non-science majors
b. To expose students to the technical aspects of HF
c. To explore the potential environmental impacts of the activities related to HF in the U.S. and specifically Michigan

General description

In this activity students will work in teams to analyze scientific research on hydraulic fracturing. This research will be examined within the historical context in the state of Michigan, where oil and gas companies have been using HF for about 50 years and most wells drilled recently also integrate horizontal drilling.

Relevant handouts

Students will read the following materials ahead of the class meeting:

- Ellis, B. (2013). Hydraulic Fracturing in the State of Michigan-Geology/Hydrogeology Technical Report. http://deepblue.lib.umich.edu/handle/2027.42/102576
- Wilson, J., & Schwank, J. (2013). Hydraulic Fracturing in the State of Michigan-Technology Technical Report. http://deepblue.lib.umich.edu/bitstream/handle/2027.42/102575/02_Technology.pdf?sequence=1&isAllowed=y

Optional readings:

- http://energy.usgs.gov/OilGas/UnconventionalOilGas/HydraulicFracturing.aspx#3892410-news
- http://www2.epa.gov/hfstudy

Logistics

a. The instructor introduces the scientific processes, and related concepts such as uncertainty, causality, randomness, etc. (30 minutes). Students share their questions, which are then grouped in categories by the instructor and answered by the group. The instructor can use the following resources from the Shorenstein Center on Media, Politics, and Public Policy at Harvard University:

- http://journalistsresource.org/tip-sheets/research/introduction-studies-academic-research-journalists
- http://journalistsresource.org/tip-sheets/research/interpreting-academic-studies-primer-media
- http://journalistsresource.org/tip-sheets/research/statistics-for-journalists

b. In small groups (3-4 students), students discuss the main components of a scientific study related to HF (30 minutes). Students are asked to examine the hypotheses, research questions, methods, results, and conclusions. The instructor floats between groups to provide feedback and recommendations.
c. Each group then develops a short summary of the scientific study or report intended for a lay audience. Each group then presents their summary and other groups provide feedback based on the scientific concepts discussed at the beginning of class (30-45 minutes).
d. Groups reconvene and the instructor moderates and guides a discussion about the scientific reports that students read in preparation for class (45 minutes).

Homework: Students will read the assigned material for module 3 described below. Students will develop 2-4 questions about the readings and post them to the online management system (e.g. Blackboard, D2L). These questions will be used in the next meeting as discussion points.

Assignment 1:

a. Students will watch either the documentary "Fracknation" or "Gasland"
b. Students will write a report that critically examines the claims made in the film
c. Refer to the attachment "*Assignment 1*" for specific instructions

Module 3
Stakeholders and the legal and policy context of HF

Purpose

a. To examine the various stakeholders involved in the decision making process
b. To examine the political and policy processes governing HF
c. To develop competencies in the understanding of the ways in which scientific outputs are used in policy making

General description

In this group activity students will work in teams following a jig saw format to analyze various political stakeholders involved in the issue.

Relevant handouts

Students will read the following materials ahead of the class meeting:

- Schroeck, N. J. (2014). Hydraulic Fracturing and Protection of Freshwater Resources in the Great Lakes State. *Ind. Int'l & Comp. L. Rev.*, *24*, 113. http://heinonline.org/HOL/Page?handle=hein.journals/iicl24&div=10&g_sent=1&collection=journals
- Skalski, A. (2013). Regulating Hydraulic Fracturing in Michigan: The Protection of Our Waters and Our People Hits Another Roadblock. *JL Soc'y*, *14*, 277. http://law.wayne.edu/journal-of-law-society/pdf/skalski_article.pdf
- Turrel, F. J. (2012). Frack Off: Is Municipal Zoning a Significant Threat to Hydraulic Fracturing in Michigan. *Wayne L. Rev.*, *58*, 279. http://www.law.msu.edu/king/2011-2012/Turrell.pdf

Optional readings:

- Konschnik, K. E., & Boling, M. K. (2014). Shale gas development: a smart regulation framework. *Environmental science & technology*, *48*(15), 8404-8416. http://blogs.law.harvard.edu/environmentallawprogram/files/2014/03/Konschnik-NAS-Shale-Gas-Paper.pdf
- Rabe, B. G. (2014). Shale play politics: The intergovernmental odyssey of American shale governance. *Environmental science & technology*, *48*(15), 8369-8375. http://pubs.acs.org/doi/abs/10.1021/es4051132

Logistics

a. Each student will be assigned to one of five groups: DEQ, environmental NGO, university scientist, industry representative, and homeowners' association.
b. Students assigned to each stakeholder will meet to discuss the main arguments developed in the assigned materials.
    i. Students will visit the website of an NGO opposing HF, an expert, an industry coalition, homeowners' association or a government coalition. Students will analyze the discourse and rhetoric, evidence, and communication tactics (30 minutes).
c. Next, new groups with one representative from each of the four stakeholder groups will be formed. Each stakeholder will report to the rest of stakeholders the main points discussed in the previous group discussions (45 minutes).
d. Using the S-E systems framework developed by Ostrom (2009), students will list the factors and actors involved in the HF system in the US. Students will use Figure 1 in the reading (see module 1) to list (1) resource units, (2) resource system, (3), governance system, and (4) users. Briefly describe two interactions between the subsystems and two outcomes from such interactions (45 minutes)
e. Each group will present to the rest of the class the main points of their discussion (30 minutes).

Some examples of websites that students can use include the following:

- http://www.fracfocus.org/ (industry coalition)
- http://www.fracfocus.org/hydraulic-fracturing-process (process)
- http://www.gwpc.org/ (NGO composed of state ground water regulatory agencies)
- http://iogcc.publishpath.com/ (multi-state government agency)

Grassroots organizations opposing HF in MI:

- http://banmichiganfracking.org/
- http://earthjustice.org/features/michigan-and-fracking#
- http://www.letsbanfracking.org/
- http://dontfrackmichigan.com/
- https://secure.sierraclub.org/site/Advocacy?cmd=display&page=UserAction&id=6470

Homework: Students will read the assigned material for module 4 described below. Students will develop 2-4 questions about the readings and post them to the online management system (e.g. Blackboard, D2L). These questions will be used in the next meeting as discussion points.

Module 4
Public opinion about HF and human impacts

Purpose

a. To examine the relationship between the political process and public opinion
b. To introduce students to social science and mass communication research principles
c. To introduce students to data analysis using social level data
d. To examine potential impacts of HF on human health

General description

Students will examine public opinion research to assess the ways in which various publics think about the issue and the associated risks.

Relevant handouts

Students will read the following materials ahead of the class meeting:

- Basu, N. (2013). Hydraulic Fracturing in the State of Michigan-Public Health Technical Report (https://deepblue.lib.umich.edu/bitstream/handle/2027.42/102578/05_Health.pdf?sequence=1&isAllowed=y)
- Public opinion in Michigan and Pennsylvania (report from National Surveys on Energy and Environment, University of Michigan). http://closup.umich.edu/files/ieep-nsee-2012-fall-fracking.pdf
- Wolske, K., & Hoffman, A. (2013). Hydraulic Fracturing in the State of Michigan-Public Perceptions Technical Report. http://deepblue.lib.umich.edu/bitstream/handle/2027.42/102581/08_Public%20Perceptions.pdf?sequence=1&isAllowed=y
- http://journalistsresource.org/studies/government/infrastructure-government/costs-shale-natural-gas-extraction-local-roads
- http://journalistsresource.org/studies/environment/energy/environmental-costs-benefits-fracking

Optional readings:

- Boudet, H., Clarke, C., Bugden, D., Maibach, E., Roser-Renouf, C., & Leiserowitz, A. (2014). "Fracking" controversy and communication: Using national survey data to understand public perceptions of hydraulic fracturing. *Energy Policy*, *65*, 57-67. http://www.sciencedirect.com/science/article/pii/S0301421513010392
- Clarke, C. E., Hart, P. S., Schuldt, J. P., Evensen, D. T., Boudet, H. S., Jacquet, J. B., & Stedman, R. C. (2015). Public opinion on energy development: The interplay of issue framing, top-of-mind associations, and political ideology. *Energy Policy*, *81*, 131-140.
- Evensen, D., Jacquet, J. B., Clarke, C. E., & Stedman, R. C. (2014). What's the 'fracking'problem? One word can't say it all. *The Extractive Industries and Society*, *1*(2), 130-136.

- Heinecke, J., Jabbari, N., & Meshkati, N. (2014). The Role of Human Factors Considerations and Safety Culture in the Safety of Hydraulic Fracturing (Fracking). *Journal of Sustainable Energy Engineering*, *2*(2), 130-151.
- Osborn, S. G., Vengosh, A., Warner, N. R., & Jackson, R. B. (2011). Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proceedings of the National Academy of Sciences*, *108*(20), 8172-8176. http://www.pnas.org/content/108/20/8172.full.pdf+
- Vengosh, A., Jackson, R. B., Warner, N., Darrah, T. H., & Kondash, A. (2014). A critical review of the risks to water resources from unconventional shale gas development and hydraulic fracturing in the United States. *Environmental Science & Technology*, *48*(15), 8334-8348. http://sites.nicholas.duke.edu/avnervengosh/files/2011/08/EST-Review-on-hydraulic-fracturing.pdf

Logistics

a. The instructor will introduce public opinion research and the role of public opinion in policy decision making (30 minutes).
b. The instructor will lead a discussion about the main findings of the public opinion studies that students read ahead of the class (45 minutes).
c. In small groups, students will further explore the public opinion reports to identify patterns or relationships in that data reported that are worth highlighting from a journalistic perspective (45 minutes).
d. The instructor will lead a discussion about public health issues related to HF outlined in the readings. These impacts include those related to public health (e.g. contaminated drinking water), social problems (e.g. employment), infrastructure (e.g. road infrastructure), and environmental pollution (e.g. greenhouse gas emissions, noise pollution) (30 minutes).

Homework: Students will read the assigned material for module 5 described below. Students will develop 2-4 questions about the readings and post them to the online management system (e.g. Blackboard, D2L). These questions will be used in the next meeting as discussion points.

Module 5
Concept Mapping

Purpose

a. To develop understandings in S-E systems
b. To develop competencies in systematic concept mapping, feedbacks and interactions

General description

In this group activity students will work in teams to develop a systems map of the S-E system of hydraulic fracturing in MI using the Mental Modeler tool available in the

website http://www.mentalmodeler.org/. This concept mapping exercise will allow students to examine stakeholders, environmental impacts, and relationships. This new mental model will be based on the systems map students developed during module 3.

Relevant handouts
Students will read the following materials ahead of the class meeting:

- http://cmap.ihmc.us/docs/theory-of-concept-maps
- http://mentalmodels.princeton.edu/about/what-are-mental-models/

Logistics

a) The instructor will introduce the concept of mental mapping using the readings listed above (15 minutes)
b) The instructor will provide an overview of the online tool (Mental Modeler) (20 minutes)
c) Students will work in small groups brainstorming ideas about the mental model (25 minutes)
d) Each group will translate the model into the online tool (25 minutes)
e) Each group will write a narrative explaining the logic underlying the model (20 minutes)
f) Each group will present, explain and defend their models (30 minutes)
g) All groups reconvene to discuss the activity, highlighting the reasons why there were differences in the models (15 minutes)

Homework: Students will read the assigned material for module 6 described below. Students will develop 2-4 questions about the methods, results or discussion sections of the studies, and post them to the online management system (e.g. Blackboard, D2L). These questions will be used in the next meeting as discussion points.

Module 6 (Two sessions, 2.5 hours each)
Media content analysis

Purpose

a. To develop competencies in journalism and mass communication research
b. To explore the role of the media in the public discourse about HF
c. To determine the presence/absence of stakeholders in media's coverage of HF
d. To determine the framing of HF by the media in Michigan.

General description

In this group activity students will work in teams to collect, analyze and interpret newspaper articles focusing on HF. Each team will hand in a quantitative analysis and a short narrative where they will interpret the results. Students will then briefly present the results of their analysis.

Relevant handouts

- Evensen, D. T., Clarke, C. E., & Stedman, R. C. (2014). A New York or Pennsylvania state of mind: social representations in newspaper coverage of gas development in the Marcellus Shale. *Journal of Environmental Studies and Sciences*, *4*(1), 65-77.
- Mazur, A. (2014). How did the fracking controversy emerge in the period 2010-2012?. *Public Understanding of Science*, 0963662514545311.

Logistics

a. Day 1
   i. The instructor leads a discussion about the main findings of the studies assigned for this day (30 minutes).
   ii. The instructor will provide an overview of Access World News (or an alternative database depending on access, such as Lexis Nexis), the academic database that will be used to collect newspaper articles (30 minutes).
   iii. Students will be assigned one media source in Michigan and they will search and download news articles from 2011 to the present (30 minutes).
   iv. Students will examine the articles by describing the main frame used by the reporter or author (e.g. environmental, political, health, economic, social, etc.). The instructor can refer to the following resources to explain frames in environmental controversies:
      1. Gamson, W. A., & Modigliani, A. (1989). Media discourse and public opinion on nuclear power: A constructionist approach. *American journal of sociology*, 1-37.
      2. Nisbet, M. C. (2009). Communicating climate change: Why frames matter for public engagement. *Environment: Science and Policy for Sustainable Development*, *51*(2), 12-23.

b. Day 2
   i. Students will continue analyzing news articles (45 minutes)
   ii. Students will share the results of their analysis (30 minutes)
   iii. The instructor will present Google Trends (https://www.google.com/trends) to students. The instructor will search for the terms hydraulic fracturing and fracking in Michigan (60 minutes)
   iv. The instructor will show how to download the data (.csv file) into a spreadsheet.

v. The instructor will introduce assignment 2.

Homework: Students will review the databases listed under Module 7.

Assignment 2:

- Students will analyze and compare media trends and online information seeking behaviors.
- Refer to attachment "*Assignment 2.*"

Module 7
Data analysis and synthesis

Purpose

a. To develop competencies in data exploration and integration
b. To integrate the various S-E components examined in the previous modules

General description

In this group activity students will work in teams to search and interpret S-E data

Relevant resources

- Major administrative datasets of the U.S. government — all in one place. From Journalist's Resource http://journalistsresource.org/tip-sheets/research/websites-u-s-federal-government-administrative-datasets
- Natural gas production per region (monthly) http://www.eia.gov/petroleum/drilling/
- Number of producing gas wells (by state): http://www.eia.gov/dnav/ng/ng_prod_wells_s1_a.htm
- Demographic data: http://www.michigan.gov/cgi/0,1607,7-158-54534---,00.html

Logistics

a. The instructor will provide an overview of the datasets (30 minutes)
b. Students will work in teams to develop research questions they could try to answer based on the data presented (30 minutes)
c. Students will examine the datasets (60 minutes)
d. Students will present their findings (30 minutes)

Assessments

Various forms of assessment will be used to determine the achievement of the learning goals and objectives outlined in this case study. These include the following:

1. In class assignment 1: Scientific report narrative
2. In class assignment 2: Conceptual map/ Stakeholder analysis (graded)
3. Assignment 1: Documentary analysis (graded)
4. Assignment 2: Media analysis (graded)
5. Media final project (graded)

The final team project (media project) will be used as both formative and summative assessment. The project will be developed throughout the duration of the case study and assessed (formative) in stages. Students will work in class and outside of class in their projects and a final evaluation will occur at the end. The interdisciplinary teams will collaborate in developing a website (students can use a free service such as Wordpress) that highlights the integration and synthesis of S-E data. This project should integrate the various in-class assignments and homework that the students will develop throughout the semester. Examples of media products include the following examples from Michigan State University (mifracksource.wordpress.com)and Lehigh University (https://marcellus.cas2.lehigh.edu). The interdisciplinary collaborative projects should be evaluated, when possible, by the instructor(s) and by additional faculty with diverse expertise on the topic.

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