Socio-Environmental Case Study Teaching Notes

Title: Balancing economic and environmental tradeoffs for dairy production in California and New Zealand

Authors: Dr. Rachael Garrett and Dr. Meredith T. Niles

Summary: This case examines the complexity of controlling for nutrients in dairy systems across New Zealand and California. Nutrients (including phosphorus and nitrogen) are of increasing concern from dairy systems in both New Zealand and California. As dairy production has increased in these regions it has provided economic opportunities and many benefits for rural areas; simultaneously, it presents new challenges for controlling nutrient pollution, which can influence both environmental quality and public health. This case examines the complexity of the issue from multiple perspectives and aims to provide students with diverse viewpoints. The case enables students to identify tradeoffs and feedbacks within systems and to critically assess how different stakeholders may have competing interests. Ultimately through in-class debates, concept mappings and presentations the students will need to determine an appropriate policy pathway forward in a given region and write a policy brief to outline the varying perspectives. The case involves multidisciplinary concepts across the ecological, agricultural, policy and social sciences and provides "real world" resources to ground the issue in the current context.

Courses appropriate for: Food systems, Environmental Science, Environmental Studies, Environmental Policy, Agricultural Policy, Rural Sociology, Socio-Ecological Systems, Resource Economics

Level: Upper undergraduate, Graduate

Size: This case is best run for a class size around 15-20.

Socio-Environmental Synthesis Learning Goals:

At the end of the case, students will be able to:

- Identify the key problems in each region
- Develop conceptual maps of the system
- Compare system complexity
- Identify multiple stakeholder perspectives
- Critically assess and debate different points of view
- Analyze key policy and management levers for system change
- Assess tradeoffs with different levers
- Create policy recommendations and compare policy feedbacks between two regions

Learning Objectives:
At the end of this course module students will be able to:
1) Describe the structure and variation within California and New Zealand dairy systems from both social and ecological perspectives
2) Conceptualize the complexity and feedbacks within a dairy nutrient regulatory environment
3) Detail varying policy options and tradeoffs for nutrient management in dairy systems
4) Construct and defend a compelling argument for a stakeholder position within the dairy systems

Introduction:
Agricultural systems are complex socio-environmental systems that involve multiple disciplines and stakeholders. Over the past decades across western agricultural systems, agriculture has achieved marked success in advancing yield frontiers and increasing the efficiency of production systems. In dairy systems, many of the yield and efficiency gains have been achieved by removing dairy from pasture and supplementing them with grains and by increasing the density of cattle within farms. While such specialization and intensification may help increase efficiency and provide for economies of scale, it creates new challenges for environmental management, rural livelihoods, and socio-cultural considerations.

This case study aims to assess the socio-environmental complexities of dairy production across California and New Zealand- two significant dairy regions with importance for dairy production globally. California is the number one producer of milk in America (21% of total US production) and New Zealand is among the world's top milk producers, the majority of which is channeled through Fonterra- a farmer owned cooperative (the 4th largest dairy company in the world). As dairy production has ramped up across these two regions, each faces increasing challenges from nitrogen pollution and water scarcity, in large part as a result of agricultural production (though not only dairy). While these challenges are similar, strategies for addressing the issue may vary based on differences within the regions including: 1) domestic versus export consumption; 2) socio-cultural norms related to agricultural production; 3) agricultural policies and price supports; 4) Biophysical characteristics of the region and climate; and 5) farmer behaviors and decision-making. This case study will engage students in thinking critically about these complexities across two regions with both similar and differing characteristics and to consider nitrogen and water policy options for each region as best suited to regional conditions.

Students will learn about core components of dairy systems including management systems, ecological processes related to animal, plant and environmental nutrient cycling, environmental and agricultural policies, and agricultural trade-offs and decision-making. This case study is designed to be taught in 3 modules (Table 1), which can be combined in one longer classroom period or multiple shorter classroom periods. The students will engage in multiple components throughout the course modules designed to build upon their increasing knowledge and understanding of complex dairy systems and to enable students to consider varying viewpoints of environmental management policies in dairy production.

Table 1: Course modules

Module	**Teaching documents needed**
Group discussion to highlight the key messages from the California and New Zealand dairy system readings and to understand all of the stakeholders.	"Case study student handout" (read before class)
Group work to develop conceptual maps to understand the structure of the California and New Zealand systems and potential leverage points for change	"Concept map teaching handout" and "Assignment student handout"
Group debate to defend stakeholder positions related to policy options and tradeoffs for nutrient management in dairy systems	"Assignment student handout"

In particular, students will:
1) Develop SES concept maps in separate groups of New Zealand and California dairy production systems considering social, environmental, policy, and economic components;
2) Share concept maps and describe systems complexity with each regional group;
3) Develop a stakeholder perspective based on scientific, socio-cultural, policy, and news information sources;
4) Brainstorm policy options for reducing nitrogen emissions and increasing water efficiency in dairy systems, which are preferable to their stakeholder perspective;
5) Debate and defend their perspective within a classroom debate;
6) After considering other perspectives and policy options, develop a policy memo (as a theoretical legislative/parliamentary staffer) for their policymaker boss about the best nitrogen and water policy options, which considers the diversified stakeholder perspectives of their many constituents;
7) Engage in peer-review of policy memos.

This case study is best taught for the aforementioned types of courses as it assumes some basic knowledge and understanding of food and agriculture systems as well as environmental, economic, and political processes. Specific knowledge of dairy systems is not necessary as core components will be discussed in introductory and background materials. The case study is best taught in the middle or end of a course in which students have been introduced to concepts related to environmental science, nutrient cycles, water policy, agricultural and food systems, global food economics, and environmental policies.

Classroom Management:
Prior to the first class students will read the student background materials outlined below.

During the first course period (50 minutes) the teacher will facilitate a group discussion asking the students to identify: i) the key socio-ecological problems identified in the readings (~20 minutes) and ii) a list of stakeholders, along with their interests and potential leverage points/behavior options (~20 minutes). The first 5 minutes of the class should be used by the teacher to describe the plan for the class period. To avoid having just a couple of students dominating the activity it is helpful to go around the class in a circle and ask every student their answers to the prompt individually. At the end of the first class the students will be asked to vote on the 3 most interesting stakeholder perspectives to explore in class period 3 (~5 minutes).

There are no new assignments between class period 1 and 2.

During the second class period (50 minutes) the students will work in small groups to develop concept maps of the system (see accompanying information), scan their maps into a digital form, and share their maps via the course website or email with the other groups.

At the end of class 2 students will be asked to send evaluations of their team's conceptual maps as well as the other groups' maps to the teacher as a form of self-assessment. After the second class students will also receive their stakeholder assignment (i.e. which of the 3 groups they will represent) and they will be asked to prepare their arguments for the class period 3.

During the third class period (50 minutes) each of the three teams will have 10 minutes to work as a group to prepare a 5-minute summary of the the changes in policy and management they would like to see in the study regions. Then each group will present their view point (~15-20 minutes). The remaining class period (20 minutes) will be allocated to rebuttals and group discussion that emerge from disagreement and consensus about different policy alternatives. If students' presentations are too short it is suggested that the teacher be prepared to come up with their own probes, clarifications, or rebuttals that require students to expand on their comments.

After the final class students will have 1 week to write up their individual 2-page policy memos, which synthesize key stakeholder points and recommend a particular policy approach.

All of the classroom activities on day 1, 2, and 3 will enable the teacher to directly evaluate that class' understanding of the core issues, however, the policy memo's will provide the most clarity on differences in understanding among individuals and each student's ability to synthesize the content complexity and write a compelling argument in favor of a particular policy approach.

Assessment:
Our case study includes four different opportunities to assess whether or not students: in-class questions (during the first class period), in-class development of the concept maps (during the second class period), in-class participation in the stakeholder debate (during the third class period), and review of the take home policy memo (Table 2). Assessment/grading criteria for the concept maps, stakeholder debate, and policy memos are provided in the student hand out. Assessment of in-class questions will be based on students' ability to articulate an accurate and thoughtful response to the questions posed by the instructor.

Table 2: Opportunities to assess whether or not students have achieved learning objectives

Learning objective	Assessment tools
Describe the structure and variation within California and New Zealand dairy systems from both social and ecological perspectives	Questions; concept maps
Conceptualize the complexity and feedbacks within a dairy nutrient regulatory environment	Concept maps
Detail varying policy options and tradeoffs for nutrient management in dairy systems	Concept maps; stakeholder debate; policy memo
Construct and defend a compelling argument for a stakeholder position within the dairy systems	Stakeholder debate; policy memo

Background (for both the students and the instructor):
This case study involves a diversity of important background information needed for the instructor to accurately teach the case and provide the correct context. This scales from the global to the regional level within the case. We provide links to specific information sources below that will help the instructor understand scientific concepts, the nitrogen issue within each region and relevant policies.

California

1. *Case study student handout-CA.docx*
2. *UC Davis Nitrogen Assessment:* http://asi.ucdavis.edu/programs/sarep/research-initiatives/are/nutrient-mgmt/california-nitrogen-assessment
3. *Agricultural nonpoint source water pollution policy: the case of California's Central Coast* http://www.sciencedirect.com/science/article/pii/S016788090800176X

4. *Individual and institutional responses to the drought: the Case of California agriculture* http://opensiuc.lib.siu.edu/jcwre/vol121/iss1/3/
5. *Challenges and Opportunities for California's Dairy Economy (Executive Summary & Appendix A – the McKinsey Report Summary).* http://cccd.coop/files/TotalReport-CaliforniaDairyChallengesAndOpportunities.pdf

New Zealand

1. *Case study student handout-NZ.docx*
2. *Dairy Dilemma:* http://www.stuff.co.nz/business/farming/dairy/10685548/New-Zealands-dairy-dilemma
3. *Mitigation of Nutrient Loss from New Zealand Agriculture:* http://www.pce.parliament.nz/media/pdfs/MitigationofNutrientLossAnastasiadisetal2012.pdf
4. *National Business Review. Fonterra's Five Biggest Challenges: Dirty Dairying:* http://www.nbr.co.nz/article/fonterra-s-five-biggest-challenges-part-v-dirty-dairying-78677
5. *Kerr et al. 2015. MOTU. Lake Taupo's Nitrogen Trading Market:* http://www.motu.org.nz/assets/Documents/our-work/environment-and-resources/nutrient-trading-and-water-quality/Motu-Note-20-Taupo-Nitrogen-Market.pdf

Global dairy

1. http://www.ifcndairy.org/media/downloads/WDM-2014-low.pdf
2. http://www.ifcndairy.org/media/pdf/publications2014/Benchmarking-Cost-of-Milk-Production-in-46-Countries.pdf
3. http://www.ifcndairy.org/media/pdf/publications2014/World-mapping-of-animal-feeding-systems-in-the-dairy-sector.pdf

Policy

1. Field, B. 2008 Chapter 7: Public Policy for Natural Resources" in Natural Resource Economics: An Introduction. Waveland Press. Long Grove, USA.

References:

Acknowledgements: This work was supported by the National Socio-Environmental Synthesis Center (SESYNC) under funding received from the National Science Foundation DBI-1052875.

Appendix:

Item 1: Sample policy memo

Grade A/A-. It could have better discussed the dynamics of the system - what exactly would happen to agricultural practices and landscapes and how that might influence food prices and consumers.

"TO: California State Governor Jerry Brown

FROM: XX Representative from the CA State Water Resources Control Board

SUBJECT: Enact local level MINAS and nitrate trading policies for nitrogen management in California

DATE: 11 / 25 / 2015

Senate Bill SBX2 1, ratified in 2008, required the California State Water Resources Control Board (State Water Board) to prepare a report to the Legislature to "improve understanding of the causes of [nitrate] groundwater contamination, identify potential remediation solutions and funding sources to recover costs expended by the State…to clean up or treat groundwater, and ensure the provision of safe drinking water to all" (Harter & Lund, 2012). After completion in 2012, the UC Davis research team, the primary consultancy agency to the State Water Board in research and compilation of the report, concluded that more than 90 percent of nitrogen contamination in California's Tulare Lake Basin and Salinas Valley comes from agricultural fertilizers (Harter & Lund, 2012). The dangers of nitrogen pollution range from environmental degradation to a multiplicity of human health concerns such as infant death, blue baby disease, gastric cancer, and thyroid and reproductive disorders (Lopez, 2013, Dowd et al., 2008). However, nitrogen is a crucial input to modern agriculture (Rosenstock et al., 2013). The issue now, is to determine how to reduce nitrogen pollution in the Tulare Lake Basin and Salinas Valley regions without further hurting local economies in the context of increasing water scarcity. We advise the state of California to enact local level governance systems such as a MINAS system and nitrate trading policy in order to manage nitrogen pollution and ensure environmental justice in California. Interested parties include the California state government, farmers, rural workers and community members, conservationists, and American consumers, among others.

Immediacy of the Issue

There is an inexorable trade off between nitrogen use for sustaining California's prominent agriculture sector and the negative externalities such as water and air pollution, depletion of the ozone layer, climate change and many human health concerns (Rosenstock et al., 2013). Nearly all of the 2.6 million residents in the two regions mentioned above rely on groundwater for everyday drinking. Although the California Department of Public Health has set forth a maximum contaminant level for nitrates in drinking water, 45 milligrams per liter, the study reported that nearly 10 percent of these residents may be drinking nitrate-contaminated water that exceed these levels (Harter & Lund, 2012). Not only is this detrimental for human health, but excessive nitrates in the groundwater have steep financial repercussions as well. In the Tulare Lake Basin and Salinas Valley regions alone, additional costs to provide safe drinking water are estimated to be nearly $20 million per year for short-term solutions and up to $36 million per year for long-term solutions (Harter & Lund, 2012).

Nitrogen pollution occurs when manure or synthetic fertilizers are improperly stored or handled at the farm level. A majority of nitrates applied to cropland is lost to the environment through leaching into groundwater, direct runoff into lakes or streams, or atmospheric losses (see figure 1). In agriculturally intensive areas, like the Tulare Lake Basin and Salinas Valley, nitrates from fertilizers have infiltrated into water basins and aquifers for centuries.

Importance of the Tulare Lake Basin and Salinas Valley

Action must be targeted strategically at the Tulare Lake Basin and Salinas Valley region. Out of the nation's five largest agricultural producing counties, four are located within Tulare Lake Basin and Salinas Valley (Harter & Lund, 2012). Juxtaposed with these large agricultural areas are some of the poorest communities in the country. These communities have little to no capacity to deal with unsafe drinking water resulting from agricultural nitrate leakage ultimately exacerbating vulnerability to human health risks.

Employing a Mineral Accounting System (MINAS)

We urge the California state government to adopt a set of local policies in order to manage excessive nitrogen levels in Tulare Lake Basin and Salinas Valley. The recommendation of the State Water Board is to employ a strategy emulating the Mineral Accounting System (MINAS) enacted in the Netherlands. MINAS is a "performance standard strategy that uses economic incentives to induce compliance" (Dowd et al., 2008). The program measures the total nitrogen input as well as output for an individual farm, the difference being the surplus. Surplus nitrogen not utilized by the crops is assumed to be lost to the environment. This level is then compared with an "environmentally safe surplus standard" or "levy free surplus (LFS)" (Dowd et al., 2008). For every kilogram above the LFS, the farmer would be taxed an excess fee. Not only would the money accumulated from the tax be used to fund safe drinking water measures, it would encourage and ultimately incentivize the farmers to use nitrogen more efficiently and sparingly.

Coupling MINAS with a Nitrate Trading System

Additionally, the MINAS system could further incentivize farmers to reduce nitrate contamination by coupling MINAS with a nitrate trading system. For every 10 kilograms (or whichever unit the State decides is appropriate) under the LFS level, farmers would be granted a permit. This permit can then be traded, for economic compensation, with other farmers who, for whatever reason, cannot cost-effectively decrease their nitrate levels. This would provide a cost effective, market-based, approach to achieve environmental and human health goals (Dowd et al., 2008).

Monitoring and Evaluation

Although we recognize that calculating the surplus nitrogen levels requires a massive amount of data, most of which is difficult to obtain (Rosenstock et al., 2013), we suggest a similar monitoring and assessment scheme employed by California's Department of Pesticide Regulation (DPR) (Harter & Lund, 2012). Currently the DPR uses a grower self-reporting system that serves as a warning sign for excess nitrogen use (Rosenstock et al., 2013). Building upon this already active system, we could more easily develop a self-reporting system for total nitrogen applications. Furthermore, the California Environmental Protection Agency, already employs a Groundwater Data Task Force, to independently examine groundwater quantity and quality problems (Harter & Lund, 2012). In combination, these two monitoring mechanisms could have great impacts on lowering nitrogen loading levels at little expense to the state.

Enact MINAS and Nitrate Trading to Ensure Environmental Justice in California

The trade off between nitrogen use for agriculture and the negative environmental and health externalities of excess nitrogen pollution need immediate attention for the State of California. We, the State Water Board, urge you, Governor Brown, to employ a MINAS system for nitrate accounting coupled with a nitrate trading system in order to achieve cost effective solutions to both lower nitrogen inputs at the farm level and offset long-term impacts of nitrate excess in drinking water by funding safer drinking options for those who have been impacted for centuries."

Item 2: Sample notes from class discussion