## The Food-Energy-Water Nexus (GEO/NRSM 595) Fall 2017

### Course Information

Class meetings: TR 12:30-1:50 pm, CHCB 333
3.0 credits
Website: Moodle umonline.umt.edu


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|---|---|---|
| Instructors: | Andrew Wilcox | Laurie Yung |
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### Overview

***The Food-Energy-Water Nexus*** examines core nexus concepts and tools with an emphasis on bridging local and global scales, sectors and disciplines, and problems and analytic tools. The course integrates physical and biological sciences, social and behavioral sciences, economics, and engineering, and covers broad frameworks such as ecosystem-based approaches, decision science, economic valuation, and complex systems theory. These frameworks are applied to specific food-energy-water problems and cases to build analytic skills and illuminate system drivers, leverage points, and cross-scale linkages. Readings draw from Montana, national, and international examples. The course is structured to highlight both disciplinary and interdisciplinary perspectives on the nexus. Active learning and student participation are essential components of the course.

### Learning Outcomes

Students in this course will:

- conceptualize and articulate cross-sector linkages and processes within the FEW nexus;
- understand the FEW nexus across local to global scales and identify cross-scalar connections;
- understand systems approaches to the FEW nexus;
- develop the capacity for interdisciplinary analysis of nexus issues and topics.

### Topics and Schedule

Wk1 8/31 Introduction to the Food-Energy-Water (FEW) Nexus

Wk2 Systems Thinking and FEW Systems I
9/5 Connecting science to problem-solving
9/7 Social-ecological systems approaches

Wk3 Systems Thinking and FEW Systems II: Biophysical and Systems Engineering Approaches

Wk4 Energy Systems
- 9/19 Global energy systems and sources
- 9/21 The politics of energy

Wk5 Energy at the FEW Nexus
- 9/26 Evaluating market and non-market impacts of energy development (Katrina Mullan, Economics)
- 9/28 Energy nexus (biophysical and engineering elements)

Wk6 Water Systems
- 10/3 Biophysical elements of water systems
- 10/5 Western water policy (Michelle Bryan, School of Law)

Wk7 Water at the FEW Nexus
- 10/10 Decision-making at the intersection of water and agriculture
- 10/12 Water nexus (biophysical and engineering elements) (Kelsey Jensco, Forest Management and Montana Climate Office)

Wk8 Food Systems
- 10/17 Biophysical elements of food systems at multiple scales
- 10/19 Industrialization of the agri-food system: Ecological and social consequences (Neva Hassanein, Environmental Studies)

Wk9 Food at the FEW Nexus
- 10/24 Hydrology and agriculture modeling (Marco Maneta, Geosciences)
- 10/26 Governance and the FEW nexus

Wk 10 Interdisciplinary FEW Case Studies
- 10/31 Indigenous issues at the FEW nexus 1 (Flathead Basin)
- 11/2 Indigenous issues at the FEW nexus 2 (Amazon River Basin)

*Saturday, Nov. 4: Field Trip*. This all-day field trip will visit multiple FEWS-related sites; details and itinerary to be provided as the trip approaches. The field trip is required and will have an associated assignment.

Wk 11 Interdisciplinary FEW Case Studies
- 11/7 Mekong River Basin
- 11/9 Coal, Colstrip, and the Powder River Basin

Wk12 Interdisciplinary FEW Case Studies
- 11/14 Fracking, the Bakken, and Sage Grouse

11/16 Biofuels and the Nexus

Wk 13 Case Study Wrap Up: Challenges and Opportunities in Interdisciplinary Analyses
(11/21 only; no class on 11/23)

Wk 14

11/28 Student research paper presentations
11/30 Student research paper presentations

Wk 15

12/5 Student research paper presentations
12/7 Student research paper presentations, Future directions in FEWS

Wk 16

12/12 Synthesis and wrap up
12/14 Synthesis and wrap up

## Readings

Because there is far more to this topic than we can possibly cover in lecture, and because this is a graduate class, an important element of your learning in this course will be from readings. Typically, each week there will be one or more readings targeted at fundamental knowledge related to that week's topic (e.g., review papers, book chapters). In addition, most weeks we will read 1-2 journal papers and spend a portion of one class section discussing them. These discussions will be designed to encourage critical thinking about primary literature and broad participation (also see Participation section below). A partial list of readings is provided below; we will develop a more specific reading list and discussion schedule as the semester progresses. Readings will typically be posted on Moodle.

## Assessment

| | Percent of Course Grade | Due Date |
|---|---|---|
| Participation | 20% | Ongoing |
| Science-Policy Brief | 10% | 10/27 |
| Problem Sets and field trip assignment | 15% | multiple |
| Case Study Presentation | 15% | In class |
| Research Paper | 30% | 12/12 |
| Paper Presentation | 10% | In class |
| Total | 100% | |

## Participation

Participation grades will be based on regular attendance and engaged participation. This is a graduate seminar, which means that students are responsible for contributing to the content of

the course through engaged participation, discussion, and presentations. Students are expected to carefully and thoroughly read ALL assigned readings prior to class and come to class prepared to discuss, examine, analyze, and critique each reading. "Engaged participation" does not refer to the number of comments you make during class or your level of expertise, but rather describes the sort of thoughtful, meaningful, prepared (meaning you *actively* read the assignments) questions and comments that further your own intellectual development and that of the group. A willingness to work on the material at hand, and consider its application to the field is critical. Civility and respect for different views and ideas are also expected. In some cases participation will entail completing in-class quantitative problem solving and back-of-the-envelope calculations.

### Science-Policy Brief

Students will be asked to write a 2-page brief, outlining the potential policy implications of a specific FEW nexus scientific finding. This paper will be written in lay language with a target audience of policy-makers, elected officials, or other decision-makers. The brief will need to connect a specific nexus finding to a proposed or existing policy. Students will need to identify a topic for this paper, based on the assigned readings for this class or resources identified outside of class. More specific guidelines for this assignment will be provided.

### Quantitative Problem Sets

There will be several short problem sets relating FEW nexus topics to material fluxes and budgets, modeling, finding and applying environmental data, and numeracy.

### Case Study Presentation

Students will be organized in small, interdisciplinary groups to research and prepare a class session related to a specific FEW nexus case study. Each group will be responsible for one day of instruction during weeks 10–12. Instructors will provide topics and a set of readings to get each group started. Each group will be meet outside of class to find additional readings and resources, discuss the key elements of the case and how to focus the class period, select specific readings for the rest of the class, and plan their case study presentation. Each group will have an assigned instructor (Yung, Wilcox, or other faculty) who will work with them to understand the case and plan the presentation.

Presentations can include lecture, guided discussion, and other class activities. Presentations need to: (1) focus on the nexus (e.g. interactions between two or more of food, energy, and water), (2) be integrated and interdisciplinary (e.g. highlight interactions across social, physical, and biological elements of the case), (3) highlight interactions across scales, and (4) present or generate some specific ideas regarding interdisciplinary research related to the case (e.g. research questions and possible methods for an interdisciplinary study of the topic).

### Research Paper

Each student will prepare a 12-15 page research paper focused on a specific FEW nexus topic, interaction, or case study. Students should consult with instructors about potential topics. If

possible, papers topics should align with the student's research interests. Topics should be focused enough to provide the opportunity for in-depth analysis. All papers must focus on the nexus (an interaction between two or more of food, energy, and water). More specific guidelines for the paper will be provided.

### Paper Presentation

Each student is required to make a short class presentation on the topic chosen for your research paper. Presentations offer students the opportunity to hone communication skills and to engage the class in their topic prior to finalizing their paper. Students should provide the class with a short reading or background information prior to the presentation. During the third week of class, students will sign up for presentation dates. Presentations will be followed by questions and discussion if time allows. Presentations will be evaluated based on your ability to effectively convey key aspects of the topic and concepts involved, original analysis, and clarity of material.

### Course website

Please check the course website (Moodle) regularly, especially before class, for announcements, notes, readings, assignments, and schedule updates. Some of the class lecture notes will be posted.

### Student Conduct Code

The Student Conduct Code at the University of Montana embodies and promotes honesty, integrity, accountability, rights, and responsibilities associated with constructive citizenship in our academic community. This Code describes expected standards of behavior for all students, including academic conduct and general conduct, and it outlines students' rights, responsibilities, and the campus processes for adjudicating alleged violations. Full student conduct code. http://www.umt.edu/vpsa/policies/student_conduct.php

### Course Withdrawal

Students may use Cyberbear to drop courses through the first 15 instructional days of the semester. Beginning the 16th instructional day of the semester through the 45th instructional day, students use paper forms to drop, add and make changes of section, grading option or credit. GEO560 may not be taken as credit/no-credit.

### Disability Modifications

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and Disability Services for Students. https://www.umt.edu/dss/default.php If you think you may have a disability adversely affecting your academic performance, and you have not already registered with Disability Services, please contact Disability Services in Lommasson Center 154 or call 406.243.2243. I will work with you and Disability Services to provide an appropriate modification.

**Journal papers for background readings and discussion (tentative, and** in approximate order of when they may be read / discussed, rather than alphabetically**)**


Jones, K., N.R. Magliocca and K. Hondula, 2017. White paper: An overview of conceptual frameworks, analytical approaches and research questions in the food-energy-water nexus. National Socio-Environmental Synthesis Center (SESYNC), University of Maryland, March 2017.

Scanlon, B.R., B.L. Ruddell, P.M. Reed, R.I Hook, C. Zheng, V.C. Tidwell, and S. Siebert. 2017. The food-energy-water nexus: Transforming science for society. *Water Resources Research* 53.

Adams, W.M., Sandbrook, C. 2013. Conservation, evidence and policy, *Fauna and Flora International*, 47, 329-335.

Stirling, A. 2010. Keep it complex, *Nature*, 468, 1029-1031.

Stirling, A. 2015. Developing "nexus capabilities:" Towards transdisciplinary methodologies. The Nexus Network.

Ostrom, E. 2009. A General Framework for Analyzing Sustainability of Social-Ecological Systems, *Science*, 325, 419-422.

Berkes, F., Colding, J., Folke, C. 2003. Introduction. From Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press. pp. 1-29.

Pittock, J., Hussey, K., Dovers, S. 2015. Climate, Energy and Water: Managing Trade-Offs, Seizing Opportunities. Cambridge University Press. SELECTED CHAPTERS

Bazilian, Morgan, Holger Rogner, Mark Howells, Sebastian Hermann, Douglas Arent, Dolf Gielen, Pasquale Steduto, et al. 2011. Considering the Energy, Water and Food Nexus: Towards an Integrated Modelling Approach. *Energy Policy* 39 (09): 7896–7906.

Greenblatt, J. B., N. R. Brown, R. Slaybaugh, T. Wilks, E. Stewart, and S. T. McCoy (2017), The Future of Low-Carbon Electricity, *Annual Review of Environment and Resources*. 42.

Holland, R. A., K. A. Scott, M. Flörke, G. Brown, R. M. Ewers, E. Farmer, V. Kapos, A. Muggeridge, J. P. Scharlemann, and G. Taylor (2015), Global impacts of energy demand on the freshwater resources of nations, *Proceedings of the National Academy of Sciences*, *112*(48), E6707-E6716.

Hodbod, J., Adger, W.N. 2014. Integrating social-ecological dynamics and resilience into energy systems research. *Energy Research and Social Science*, 1, 226-231.

Select public opinion polling results from Gallup, Pew, etc.

Olson-Hazboun, S.K., Krannich, R.S., Robertson, P.G. 2016. Public views on renewable energy in the
Rocky Mountain region of the United States: Distinct attitudes, exposure, and other key predictors of wind energy. *Energy Research and Social Science*, 21, 167-179.

Klein, E. 2014. How Politics Makes Us Stupid. *Vox*. April 6, 2014.

Muehlenbachs, L., Spiller, E., Timmins, C. 2015. The Housing Market Impacts of Shale Gas Development. *American Economic Review,* 105(12): 3633–3659.

Pekel, J.-F., A. Cottam, N. Gorelick, and A. S. Belward (2016), High-resolution mapping of global surface water and its long-term changes, *Nature*, *540*(7633), 418-422.

Yamazaki, D., and M. A. Trigg (2016), Hydrology: The dynamics of Earth's surface water, *Nature*, *540*(7633), 348-349.

Wagener, T., M. Sivapalan, P. A. Troch, B. L. McGlynn, C. J. Harman, H. V. Gupta, P. Kumar, P. S. C. Rao, N. B. Basu, and J. S. Wilson (2010), The future of hydrology: An evolving science for a changing world, *Water Resources Research*, *46*(5).

McMahon, J. E., and S. K. Price (2011), Water and energy interactions, *Annual Review of Environment and Resources*, *36*, 163-191.

Rodriguez, D. et al. Adding to complexity: Climate change in the energy-water nexus. In Dodd, F. and J. Bartram, eds. 2016. *The Water, Food, Energy, and Climate Nexus: Challenges and An Agenda for Action*. London: Routledge

Dunn, M.R., Lindesay, J.A., and Howden, M. 2015. Spatial and temporal scales of future climate information for climate change adaptation in viticulture: a case study of User needs in the Australian winegrape sector. *Australian Journal of Grape and Wine Research* 21:226–239.

Crane, T.A., Roncoli, C., Paz, J., Breuer, N., Broad, K., Ingram, K.T., and Hoogenboom, G. 2010. Forecast skill and farmers' skills: Seasonal climate forecasts and agricultural risk management in the southeastern United States. *Weather, Climate, and Society* 2:44–59.

Foley, J. A., N. Ramankutty, K. A. Brauman, E. S. Cassidy, J. S. Gerber, M. Johnston, N. D. Mueller, C. O'Connell, D. K. Ray, and P. C. West (2011), Solutions for a cultivated planet, *Nature*, *478*(7369), 337-342.

Vermeulen, S. J., B. M. Campbell, and J. S. Ingram (2012), Climate change and food systems, *Annual Review of Environment and Resources*, *37*.

Belmont, P., and E. Foufoula-Georgiou (2017), Solving water quality problems in agricultural landscapes: New approaches for these nonlinear, multiprocess, multiscale systems, *Water Resources Research*, *53*(4), 2585-2590.

Dalin, C., Y. Wada, T. Kastner, and M. J. Puma (2017), Groundwater depletion embedded in international food trade, *Nature*, *543*(7647), 700-704.

West, P. C., H. K. Gibbs, C. Monfreda, J. Wagner, C. C. Barford, S. R. Carpenter, and J. A. Foley (2010), Trading carbon for food: Global comparison of carbon stocks vs. crop yields on agricultural land, *Proceedings of the National Academy of Sciences*, *107*(46), 19645-19648.

Bao, X., and D. W. Eaton (2016), Fault activation by hydraulic fracturing in western Canada, S*cience*.

Elsworth, D., C. J. Spiers, and A. R. Niemeijer (2016), Understanding induced seismicity, *Science*, *354*(6318), 1380-1381.

Gallegos, T. J., B. A. Varela, S. S. Haines, and M. A. Engle (2015), Hydraulic fracturing water use variability in the United States and potential environmental implications, *Water resources research*, *51*(7), 5839-5845.

Jackson, R. B., A. Vengosh, J. W. Carey, R. J. Davies, T. H. Darrah, F. O'sullivan, and G. Pétron (2014), The environmental costs and benefits of fracking, *Annual Review of Environment and Resources*, *39*, 327-362.

Ewing M, Msangi S. 2009. Biofuels production in developing countries: Assessing tradeoffs in welfare and food security. *Environmental Science and Policy* 12:520-528.

Tilman et al 2009. Beneficial biofuels: Food energy environment trilemma. *Science*.

Chikkatur, A. P, Ankur Chaudhary, and Ambuj D. Sagar. 2011. Coal Power Impacts, Technology, and Policy: Connecting the Dots**,** *Annual Review of Environment and Resources*. 36, 101–138

Pahl-Wostl, C. 2017. Governance of the Water-Energy-Food Security Nexus: A Multi-Level Coordination Challenge. *Environmental Science and Policy*. https://doi.org/10.1016/j.envsci.2017.07.017

Weitz, N., Strambo, C., Kemp-Benedict, E., Nilsson, M. 2017. Closing the governance gaps in the water-energy-food nexus: Insights from integrative governance. *Global Environmental Change* 45:165-173.

Hussey, K., and J. Pittock (2012), The energy–water nexus: managing the links between energy and water for a sustainable future, *Ecology and Society*, *17*(1), 31.

Portney, K.E., Hannibal, B., Goldsmith, C., McGee, P., Liu, X., Vedlitz, A. 2017. Awareness of the Food–Energy–Water Nexus and Public Policy Support in the United States: Public Attitudes Among the American People. *Environment and Behavior*, 1–26

Sarewitz, D. 2016. Saving Science. The New Atlantis. Summer/Spring, 5-40.

Wichelns, D. 2017. The water-energy-food nexus: Is the increasing attention warranted, from either a research or policy perspective? *Environmental Science & Policy* 69: 113-123.

Nature Editorial Group. 2016. Buzzword off: 'Nexus' is enjoying new-found popularity. But what does it actually mean? *Nature*, 538, 140.