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GEO 540.01: The Food-Energy-Water Nexus

Andrew C. Wilcox
University of Montana - Missoula, andrew.wilcox@umontana.edu

The Food-Energy-Water Nexus (GEO/NRSM 540) Fall 2018

Course Information

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

Instructors:	Andrew Wilcox	Laurie Yung
Office:	CHCB 357	CHCB 463
Email:	andrew.wilcox@umontana.edu	laurie.yung@umontana.edu
Office Hours:	M 3-4 pm, or by appt (please email)	By appt (please email)

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 interdisciplinarity, systems thinking, vulnerability, governance, and connecting science and practice. 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, collaboration, and student engagement and participation are essential components of the course.

Learning Outcomes

Students in this course will:

- conceptualize and articulate cross-sector linkages and processes within the Food-Energy-Water Systems (FEWS) nexus;
- understand the FEWS nexus across local to global scales and identify cross-scalar connections;
- understand systems approaches to the FEWS nexus;
- develop the capacity for interdisciplinary and collaborative analysis of nexus issues and topics.

Topics and Schedule

Week 1 (8/28, 8/30): Introduction to the Food-Energy-Water Systems (FEWS) Nexus

Weeks 2 – 4: Core Concepts at the Nexus

9/4-9/13 Case Study: The FEWS nexus in the Mekong River Basin
9/18 Case study concept map activity

Weeks 4 – 6: Energy Systems at the Nexus

9/20 Energy politics
9/25 Renewable energy policy (Diana Maneta)
9/27 Global energy systems and sources
10/2 Paper discussion
10/4 Student presentations: science-policy/practice briefs

Weeks 7 – 9: Food Systems at the Nexus

10/9 Agroecology (Maged Nosshi)
10/11 The industrial food system (Neva Hassanein)
10/16 Hydrology and agriculture; modeling approaches: (Marco Maneta)
10/18 Drought and farmer decision-making
10/23 Paper discussion

Weeks 9 – 10: Water Systems at the Nexus

10/25 Physical process and engineering elements of water systems
10/30 Aquatic ecology at the nexus (Ben Colman)
11/1 Paper discussion

Weeks 11 – 13: Interdisciplinary FEW Case Studies

11/6 Election Day (no class)
11/8 Group 1
11/13 Group 2
11/15 Group 3
11/20 Group 4
11/22 Thanksgiving (no class)

Weeks 14 – 16: Emerging Topics, Future Directions in FEWS

11/27 Emerging INFEWS topics
11/29 Interdisciplinary analysis / Individual project short presentations
12/4 Emerging INFEWS topics; Future directions in FEWS
12/6 Course wrap up
12/11 Course wrap up; Evaluations

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). Some weeks we will also read 1-2 journal papers and spend all or a portion of class 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 be posted on Moodle.

Assessment

	Percent of Course Grade	Due Date
Participation	25%	Ongoing
Science-Policy/Practice Brief	20%	10/9
Case Study Presentation	20%	11/8-11/20
Interdisciplinary Analysis Paper and Presentation	35%	11/29 (presentation) 12/11 (paper)
Total	100%	

Participation

Participation grades will be based on regular attendance and engaged participation, including but not limited to classes devoted to paper discussions. This is a graduate seminar, which means that students are responsible for contributing to the content of the course through regular attendance, 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; quality of contributions is more important than quantity! 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. Providing space for others to contribute and knowing when to hold back are critical. Participation may also entail completing in-class quantitative problem solving and back-of-the-envelope calculations.

Science-Policy/Practice Brief

Students will be asked to write a briefing paper that outlines the potential policy or management implications of a specific FEW nexus scientific finding. This paper will be written in lay language for a target audience of a specific client or stakeholder relevant to your topic; these could include policy-makers, resource managers, non-profit personnel, or other decision-makers. The brief will need to connect a specific nexus finding to a proposed or existing policy or management action. Students will need to identify a topic for this paper, based on the assigned readings for this class or resources identified outside of class. A broad objective of this assignment is to develop your ability to connect science and practice (i.e., policy, management, solutions). Each student is also required to make a short class presentation on the topic chosen for your science-policy brief. More specific guidelines for this assignment will be provided.

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 11–13. 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).

Interdisciplinary Analysis Paper and Presentation

Each student will individually research and prepare a ~8 page paper that connects science from at least two disciplines to a FEWS problem and proposes a solution. Students will be expected to connect the disciplines, incorporate conceptual frameworks introduced in readings and class, and prepare a paper with intellectual rigor and depth suitable to a graduate course. More specific guidelines for this assignment will be provided.

Each student is required to make a short class presentation on the topic chosen for your research paper. These presentations will be “lightning talks”: 4-5 minutes long, offering students the opportunity to hone concise communication skills and to engage the class in their topic prior to finalizing their paper, as well as providing the class as a whole with exposure to a broad range of interdisciplinary research at the food-energy-water nexus. Students should provide the class with a short reading or background information prior to the presentation. 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. http://www.umt.edu/student-affairs/dean-of-students/default.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 the course, with advisor & instructor signatures. This class 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 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. We will work with you and Disability Services to provide an appropriate modification.

Journal papers for background readings and discussion (tentative; we won't read / discuss all of these)

Mekong Case Study:

Grumbine, R. E., Dore, J., & Xu, J. (2012). Mekong hydropower: drivers of change and governance challenges. *Frontiers in Ecology and the Environment, 10*(2), 91-98.

Sabo, J. L., Ruhi, A., Holtgrieve, G. W., Elliott, V., Arias, M. E., Ngor, P. B., et al. (2017). Designing river flows to improve food security futures in the Lower Mekong Basin. *Science, 358*(6368). doi: 10.1126/science.aao1053.

Halls, A. S., & Moyle, P. B. (2018). Comment on "Designing river flows to improve food security futures in the Lower Mekong Basin". *Science, 361*(6398). doi: 10.1126/science.aat1989

Williams, J. G. (2018). Comment on "Designing river flows to improve food security futures in the Lower Mekong Basin". *Science, 361*(6398). doi: 10.1126/science.aat1225

Holtgrieve, G. W., Arias, M. E., Ruhi, A., Elliott, V., Nam, S., Ngor, P. B., et al. (2018). Response to Comments on "Designing river flows to improve food security futures in the Lower Mekong Basin". *Science, 361*(6398). doi: 10.1126/science.aat1477

The Economist, 2016, Requiem for a River: Can One of the World's Great Waterways Survive its Development?, https://www.economist.com/news/essays/21689225-can-one-world-s-great-waterways-survive-its-development.

Other readings:

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

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

Bazilian, M., H. Rogner, M. Howells, S. Hermann, D. Arent, D. Gielen, P. Steduto, et al. 2011. Considering the Energy, Water and Food Nexus: Towards an Integrated Modelling Approach. *Energy Policy* 39 (09): 7896–7906.

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.

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.

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

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.

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

D'Odorico, P., Davis, K. F., Rosa, L., Carr, J. A., Chiarelli, D., Dell'Angelo, J., et al. (2018). The global food-energy-water nexus. *Reviews of Geophysics*, *56*. https://doi.org/10.1029/2017RG000591.

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.

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

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

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.

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.

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.

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

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.

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.

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.

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.

Mann, C.C. 2018. Can Planet Earth Feed 10 Billion People? The Atlantic, March; https://www.theatlantic.com/magazine/archive/2018/03/charles-mann-can-planet-earth-feed-10-billion-people/550928/

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

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

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

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.

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

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

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.

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

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

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

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

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.

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

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

Stockholm Environmental Institute. 2018. Where is the added value? A review of the water-energy-food nexus literature. SEI Working Paper, June 2018 (S. Galaitsi, J. Veysey, A. Huber-Lee).

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

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

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).

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.

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.

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.

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