

## **Adaptive Water Management in Agriculture**

GEOG 696J (Water Resources Geography) Seminar, Fall Semester 2008  
Thursdays, 2:00 – 4:30 p.m.  
Harvill Room 111

### **Instructor**

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Harvill Room 410 (phone 626-8473), or  
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### **Seminar summary**

Globally, irrigation is the largest user of fresh water and is widely viewed as the hydro-buffer for societal adaptation to climate change. Yet rising demand for food and biofuels drives irrigation withdrawals from rivers and groundwater, with important social and ecological implications. This Geography & Regional Development seminar addresses rapidly evolving agricultural water use, management, and policy at a range of scales in the context of expanding cities and variable climate. Readings draw from U.S. and international experience; topics include food production and security, climate scenarios for agriculture, ag-urban water transfers, 'more crop per drop,' virtual water, wastewater & water reuse, watershed water harvesting, and other adaptive strategies.

### **What can students expect to gain from this seminar?**

This is an opportunity to refine your interests related to water resources, global change, inter-sectoral water allocation, and policy with particular attention to the pivotal role agriculture plays. I emphasize a geographical perspective on international and transboundary dimensions of adaptive water management, and promote inter-disciplinary scholarship. I strongly encourage you to use seminar discussions and the research paper as the means to fine-tune your own research design and make headway on thesis/dissertation research and writing. Please feel free to contact me if you need further information.

### **Seminar objectives**

1. Place societal water use and dependence in the broader context of global change
2. Sample the literature on the theory and application of water supply, demand, and policy
3. Identify and discuss the role of agriculture and irrigation in complex human-natural systems
4. Explicitly consider the scale of water resource implications for and from agriculture through analysis of local, regional, national, and global processes
5. Relate seminar content to your experience and provide insights that should be useful in your future
6. Write a scholarly, instructor-approved seminar research paper
7. Build inter-disciplinary bridges among students and faculty across campus and beyond

### **Requirements**

Students must actively participate in seminar discussions, and must write an original research paper (min. 20 pages, double-spaced) that is conceptualized, researched, orally presented in seminar (with feedback from the instructor and fellow students), and finalized as part of the course.

There is no pre-requisite for this course.

### Grading policy

Grades are based on regular participation in seminar discussions, in-class presentation of your research paper, and satisfactory revision and submission of your research paper. Using the rubrics below, regular grades (A, B, C, D, or E) will be awarded upon completion of the seminar.

#### Seminar participation (total 30%) based on:

20% - Lead min. two discussions of readings

10% - Join discussions led by others

#### Expectation for A-grade

*Clearly relate theory/ main argument to broader context, pose questions for discussion & conceptual development. Insightful comments showing you have read the material.*

#### Research paper (total 70%) based on:

5% - Abstract & prelim. lit review (due 9/18)

*Descriptive title, articulate research question, 10 annotated references (not including seminar readings).*

Presentation (during 11/20 seminar)

5% - Assessment by fellow students

10% - Assessment by instructor

50% - Final paper (due 12/4)

*Effective communication, intriguing topic. Concisely summarize research questions and findings. Review literature, identify theoretical/ conceptual gaps in which to situate your research, demonstrate analytical rigor, relate findings/ discussion to theory and concept, explore ways forward/ next steps.*

### Invited speakers

9/11	Gregg Garfin, Institute for the Study of Planet Earth Connie Woodhouse, Dept. Geography & Regional Development
9/25	George Frisvold, Dept. Agricultural & Resource Economics
10/2	Sharon Megdal, Water Resources Research Center Charles Gerba, Dept. Soil, Water & Environmental Science
11/13	Paul Brown, Dept. Soil, Water & Environmental Science
12/4	Barbara Morehouse, Institute for the Study of Planet Earth Robert Varady, Udall Center for Studies in Public Policy

### Course materials

Shah, Tushaar. 2008. Taming the Anarchy: Groundwater Governance in South Asia. Resources for the Future Press, Washington.

National Research Council. 2007. Water Implications of Biofuels Production in the United States. National Academies Press, Washington.

Journal articles and book chapters will be posted on the course D2L website or distributed in class.

### Seminar policies

All students should be familiar with the following University of Arizona policies:

- Student Code of Conduct: <http://web.arizona.edu/~studpubs/policies/studcofc.htm>
- Code of Academic Integrity: <http://web.arizona.edu/~studpubs/policies/cacaint.htm>

### Students with disabilities

Please register with the Disability Resource Center and see me in order to accommodate any special needs you may have.

**SCHEDULE of TOPICS** (subject to revision as agreed/ announced)

Date	Topic	Reading / Notes
8/28	Global change: climate, growth, energy, and food trade	<p>Summer 2008 press coverage on food, energy, agriculture, and water</p> <p>Babcock, B. 2008. Breaking the link between food and biofuels. <i>Iowa Ag Review</i> 14(3): 1-3,8,9.</p> <p>Vörösmarty, Charles J., Pamela Green, Joseph Salisbury, Richard B. Lammers. 2000. Global water resources: Vulnerability from climate change and population growth. <i>Science</i> 289: 284-287. DOI 10.1126/science.289.5477.284</p> <p>Wood, W. 2008. "New" water. <i>Ground Water</i> 6(24): 517.</p>
9/4	The 'adaptive' in adaptive management: ecological and institutional roots of an emerging paradigm	<p>Gunderson, L. 1999. Resilience, flexibility and adaptive management - - antidotes for spurious certitude? <i>Conservation Ecology</i> 3(1): 1-8. [online] URL: <a href="http://www.consecol.org/vol3/iss1/art7/">http://www.consecol.org/vol3/iss1/art7/</a></p> <p>Ostrom, E. 2007. A diagnostic approach for going beyond panaceas. <i>Proceedings of the National Academy of Sciences</i> 104(39): 15181–15187. DOI 10.1073 pnas.0702288104</p> <p>O'Brien, K.L. and R.M. Leichenko. 2000. Double exposure: Assessing the impacts of climate change within the context of economic globalization. <i>Global Environmental Change</i> 10: 221-232.</p> <p>Pahl-Wostl, Claudia. 2007. Transitions towards adaptive management of water facing climate and global change. <i>Journal Water Resources Management</i> 21(1): 49-62. DOI 10.1007/s11269-006-9040-4</p> <p><i>Recommended reading:</i></p> <p>Holling, CS (ed). 1978. <u>Adaptive Environmental Assessment and Management</u>. John Wiley and Sons, New York.</p> <p>Walters, C. 1986. <u>Adaptive Management of Renewable Resources</u>. MacMillan, New York, 374 pp.</p>
9/11	Climate extremes and water resources variability	<p>Garfin, G., M.A. Crimmins, and K.L. Jacobs. 2007. Drought, climate variability, and implications for water supply and management. In B.G. Colby and K.L. Jacobs (eds.), <u>Arizona Water Policy</u>. Resources for the Future Press, Washington DC, pp. 61-78.</p> <p>Woodhouse, Connie A., Stephen T. Gray, David M. Meko. 2006. Updated streamflow reconstructions for the Upper Colorado River Basin. <i>Water Resources Research</i> 42, W05415, doi:10.1029/2005WR004455.</p>

9/11	(continued)	<p>Ray, A.J., G.M. Garfin, M. Wilder, M. Vásquez-León, M. Lenart, and A. Comrie. 2007. Applications of monsoon research: opportunities to inform decisionmaking and reduce regional vulnerability. <i>Journal of Climate</i> 20:1608-1627.</p> <p>Milly, P.C.D., Julio Betancourt, Malin Falkenmark, Robert M. Hirsch, Zbigniew W. Kundzewicz, Dennis P. Lettenmaier, Ronald J. Stouffer. 2008. Stationarity is dead: Whither water management? <i>Science</i> 319: 573-574. doi 10.1126/science.1151915</p> <p>Lobell, David B., Christopher B. Field. 2007. Global scale climate–crop yield relationships and the impacts of recent warming. <i>Environmental Research Letters</i> 2 (March 2007) 014002. doi:10.1088/1748-9326/2/1/014002</p> <p><i>Recommended reading:</i></p> <p>Pollard, Jane S., Jonathan Oldfield, Samuel Randalls, John E. Thornes. 2008. Firm finances, weather derivatives and geography. <i>Geoforum</i> 39: 616–624.</p> <p>Bierbaum, R. 2008. Coping with climate change: A national summit. <i>Environment</i> 50(4): 59-64.</p> <p>Climate Change Science Program (CCSP). 2008. <u>The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity</u>. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington, 362 pp.</p>
9/18	Water, agriculture, behemoths, basket-cases	<p><b>Abstract and preliminary literature review for research paper due.</b></p> <p>Molden, David, Karen Frenken, Randolph Barker, Charlotte de Fraiture, Bancy Mati, Mark Svendsen, Claudia Sadoff, C. Max Finlayson. 2007. Trends in water and agricultural development (pp. 57-89). In David Molden (ed.) <u>Water for Food, Water for Life</u>. Earthscan, London; International Water Management Institute, Colombo.</p> <p>Jewitt, S and K. Baker. 2007. The Green Revolution re-assessed: Insider perspectives on agrarian change in Bulandshahr District, Western Uttar Pradesh, India. <i>Geoforum</i> 38(1): 73-89.</p> <p>O'Brien, Karen, Robin Leichenko, Ulka Kelkar, Henry Venema, Guro Aandahl, Heather Tompkins, Akram Javed, Suruchi Bhadwal, Stephan Barg, Lynn Nygaard, Jennifer West. 2004. Mapping vulnerability to multiple stressors: climate change and globalization in India. <i>Global Environmental Change</i> 14: 303–313.</p> <p>Verdin, James and Robert Klaver. 2002. Grid-cell-based crop water accounting for the famine early warning system. <i>Hydrological Processes</i> 16: 1617–1630.</p> <p><i>Recommended reading:</i></p> <p>Das, Raju J. 2002. The green revolution and poverty: A theoretical and empirical examination of the relation between technology and society. <i>Geoforum</i> 33 (2002): 55-72.</p>

9/25	Water for growth: are ag-urban water transfers inevitable?	<p>Colby, Bonnie G., Katharine L. Jacobs, Dana R. Smith. 2007. Lessons for semi-arid regions facing growth and competition for water. In BG Colby and KL Jacobs (eds.), <u>Arizona Water Policy</u>. RFF Press, Washington, pp. 219-234.</p> <p>Frisvold, George, Paul N. Wilson, Robert Needham. 2007. Implications of federal farm policy and state regulation on agricultural water use. In BG Colby and KL Jacobs (eds.), <u>Arizona Water Policy</u>. RFF Press, Washington, pp. 137-156.</p> <p>San Diego County Water Authority. 2006. Canal Lining Projects Factsheet.</p> <p>MacDonald, Glen M. 2007. Severe and sustained drought in southern California and the West: Present conditions and insights from the past on causes and impacts. <i>Quaternary International</i> 173–174: 87–100.</p> <p>Swyngedouw, E. 2004. The urban conquest of water in Guayaquil, 1945-2000: Bananas, oil, and the production of water scarcity. in <u>Social Power and the Urbanization of Water. Flows of Power</u>. Oxford Univ. Press, New York, pp. 102-115.</p> <p><i>Recommended reading:</i> Swyngedouw, E. 2004. <u>Social Power and the Urbanization of Water. Flows of Power</u>. Oxford University Press, New York (only Chap. 5 assigned above).</p> <p>Swyngedouw, E. 1997. Power, nature, and the city. The conquest of water and the political ecology of urbanization in Guayaquil, Ecuador: 1880-1990. <i>Environment and Planning A</i> 29(2): 311-332.</p> <p>Newlin, Brad D., Marion W. Jenkins, Jay R. Lund, and Richard E. Howitt. 2002. Southern California water markets: potential and limitations. <i>Journal of Water Resources Planning and Management</i> 128(1): 21-32.</p>
10/2	Water reuse, effluent, and decision-making: The 'human water cycle'	<p>Gerba, C.P. and J.B. Rose. 2003. International guidelines for water recycling: microbiological considerations. <i>Water Supply</i> 3(4): 311–316.</p> <p>Megdal, Sharon B. 2006. Municipal water reuse in Tucson, Arizona, USA. Paper presented at NATO workshop on water security.</p> <p>Qadir, Manzoor, Dennis Wichelns, Liqa Raschid-Sally, Paramjit Singh Minhas, Pay Drechsel, Akiça Bahri, and Peter McCormick. 2007. Agricultural use of marginal-quality water—opportunities and challenges (pp. 425-457). In David Molden (ed.) <u>Water for Food, Water for Life</u>. Earthscan, London; International Water Management Institute, Colombo.</p> <p>Hamilton, Andrew J., Frank Stagnitti, Xianzhe Xiong, Simone L. Kreidl, Kurt K. Benke, and Peta Maher. 2007. Wastewater irrigation: The state of play. <i>Vadose Zone Journal</i> 6(4): 823-840.</p> <p>Marks, J.S. 2006. Taking the public seriously: the case of potable and non potable reuse. <i>Desalination</i> 187: 137–147.</p> <p><i>Recommended reading:</i> Scott, C.A, N.I. Faruqui, L. Rachid-Sally (eds.) 2004. <u>Wastewater Use in Irrigated Agriculture</u>. CABI Publishing, Wallingford, U.K.</p>

10/9	The water-energy nexus	<p>Scott, C.A. and T. Shah. 2004. Groundwater overdraft reduction through agricultural energy policy: insights from India and Mexico. <i>International Journal of Water Resources Development</i> 20(2): 149-164.</p> <p>Lofman, D., M. Petersen, A. Bower. 2002. Water, energy and environment nexus: The California experience. <i>International Journal of Water Resources Development</i> 18(1): 73-85.</p> <p><i>Recommended reading:</i></p> <p>Smil, Vaclav. 2005. <u>Energy at the Crossroads: Global Perspectives and Uncertainties</u>. MIT Press, Cambridge. 443 pp.</p>
10/16	Biofuels: energy & water crises?	<p>National Research Council. 2007. <u>Water Implications of Biofuels Production in the United States</u>. National Academies Press, Washington.</p> <p>Varghese, S. 2007. Biofuels and global water challenges. Institute for Agriculture and Trade Policy, Minneapolis.</p> <p>Rosegrant, Mark W., Tingju Zhu, Siwa Msangi, Timothy Sulser. 2008. Global scenarios for biofuels: impacts and implications. Allied Social Science Associations Annual Meeting. New Orleans, LA, January 4-6, 2008.</p>
10/23	Groundwater: revolution and silent crisis	<p>Shah, Tushaar. 2008. <u>Taming the Anarchy: Groundwater Governance in South Asia</u>. Resources for the Future Press, Washington.</p> <p>Loaiciga, Hugo A. 2003. Climate change and ground water. <i>Annals of the Association of American Geographers</i> 93(1): 30-41.</p> <p>Birkenholtz, T. 2008. Contesting expertise: The politics of environmental knowledge in northern Indian groundwater practices. <i>Geoforum</i> 39:466-482.</p> <p><i>Recommended reading:</i></p> <p>Shomaker, John. 2007. What shall we do with all of this ground water? <i>Natural Resources Journal</i> 47: 781-791.</p> <p>White, Stephen E. 1994. Ogallala oases: Water use, population redistribution, and policy implications in the high plains of western Kansas, 1980-1990. <i>Annals of the Association of American Geographers</i> 84:(1) 29-45.</p> <p>Shah, Tushaar, Aditi Deb Roy, Asad S. Qureshi, Jinxia Wang. 2003. Sustaining Asia's groundwater boom: An overview of issues and evidence. <i>Natural Resources Forum</i> 27(2): 130-141.</p>

10/30	Global food markets and virtual water	<p>Chapagain, Ashok K., Arjen Y. Hoekstra. 2008. The global component of freshwater demand and supply: an assessment of virtual water flows between nations as a result of trade in agricultural &amp; industrial products. <i>Water International</i> 33(1):19-32.</p> <p>Brannstrom, C. 2004. Environmental policy reform on north-eastern Brazil's agricultural frontier. <i>Geoforum</i> 36(2): 257-271.</p> <p>McAfee, Kathleen. 2008. Beyond techno-science: Transgenic maize in the fight over Mexico's future. <i>Geoforum</i> 39: 148-160.</p> <p>Raynolds, Laura T. 2004. The globalization of organic agro-food networks. <i>World Development</i> 32(5): 725-743.</p> <p>Yang, Hong, Alexander Zehnder. 2001. China's regional water scarcity and implications for grain supply and trade. <i>Environment and Planning A</i> 33: 79-95.</p> <p><i>Recommended reading:</i></p> <p>Morgan, Kevin, Terry Marsden and Jonathan Murdoch. 2006. <u>Worlds of Food: Place, Power, and Provenance in the Food Chain</u>. Oxford University Press, New York.</p> <p>Goodman, Michael K. 2004. Reading fair trade: political ecological imaginary and the moral economy of fair trade foods. <i>Political Geography</i> 23(7): 891-915.</p> <p>Erickson, Marilyn C., and Michael P. Doyle. 2008. Summary and perspectives of the impact of imported food on the microbiological safety of the United States' food supply. In M. Doyle and M.C. Erickson (eds.) <u>Safety of Imported Foods: Microbiological Issues and Challenges</u>. American Society of Microbiology.</p>
11/6	A bowl of rice: water to feed the billions	<p>Bouman, Bas, Randolph Barker, Elizabeth Humphreys, To Phuc Tuong. 2007. Rice: feeding the billions (pp. 515-549). In David Molden (ed.) <u>Water for Food, Water for Life</u>. Earthscan, London; International Water Management Institute, Colombo.</p> <p>Stoop, Willem A., Norman Uphoff, Amir Kassam. 2002. A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. <i>Agricultural Systems</i> 71(3): 249-274.</p> <p>McDonald, A.J., P.R. Hobbs, S.J. Riha. 2006. Does the system of rice intensification outperform conventional best management?: A synopsis of the empirical record. <i>Field Crops Research</i> 96(1): 31-36.</p> <p><i>Recommended reading:</i></p> <p>Brown, Lester R. 2008. Feeding eight billion well (Ch. 9). <u>Plan B 3.0: Mobilizing to Save Civilization</u>. Earth Policy Institute, Washington.</p>

11/13	Water productivity and efficiency: 'more crop per drop' and its limits	<p>Molden, David, Theib Y. Oweis, Pasquale Steduto, Jacob. W. Kijne, Munir A. Hanjra, Prem S. Bindraban. 2007. Pathways for increasing agricultural water productivity (pp. 279-310). In David Molden (ed.) <i>Water for Food, Water for Life</i>. Earthscan, London; International Water Management Institute, Colombo.</p> <p>Jenkins, Matt. 2007. The efficiency paradox. <i>High Country News</i> Vol. 2 No. 39 February 5, 2007.</p> <p>Uphoff, Norman, Amir Kassam, Willem Stoop. 2008. A critical assessment of a desk study comparing crop production systems: The example of the 'system of rice intensification' versus 'best management practice'. <i>Field Crops Research</i> 108(1): 109-114.</p> <p>McDonald, A.J., P.R. Hobbs, S.J. Riha. 2008. Stubborn facts: Still no evidence that the System of Rice Intensification out-yields best management practices (BMPs) beyond Madagascar <i>Field Crops Research</i>, In Press, Corrected Proof, Available online 21 July 2008.</p>
11/20		<b>Research paper presentations during seminar; discussion &amp; feedback</b>
12/4	Adaptive strategies: local to global	<p><b>Final paper due</b></p> <p>Morehouse, Barbara J., Daniel B. Ferguson, Gigi Owen, Anne Browning-Aiken, Pablo Wong-Gonzalez, Nicolás Pineda and Robert Varady. 2007. Science and socio-ecological resilience: Examples from the Arizona-Sonora Border. <i>Environmental Science &amp; Policy</i> 11(3): 272-284. doi:10.1016/j.envsci.2007.07.007</p> <p>Varady, Robert G., Katharine Meehan, John Rodda, Emily McGovern, and Matthew Iles-Shih. 2008. Strengthening global water initiatives. <i>Environment</i> 50(2): 19-31.</p> <p>Wester, P. 2008. When the pumps run dry: Arresting groundwater depletion in Guanajuato. In <i>Shedding the Waters</i> (PhD dissertation, pp. 173-207 <b>and conclusions and references</b>). Wageningen University, The Netherlands.</p> <p><i>Recommended reading:</i></p> <p>Brown, Lester R. 2008. <i>Plan B 3.0: Mobilizing to Save Civilization</i>. Earth Policy Institute, Washington.</p> <p>Rosegrant, Mark W., Ximing Cai, Sarah A. Cline. 2002. <i>World Water and Food to 2025: Dealing with Scarcity</i>. International Food Policy Research Institute, Washington.</p>

### Final note

All information contained in this syllabus, except the grading policy, may be subject to change with reasonable advance notice, and considering student input.