WATER RESOURCES
GEOG 574
Instructor: Dr Trent Biggs
TTh 2:00-3:15pm

Office hours: TTh 330-430
Office: 317 Storm
tbiggs@mail.sdsu.edu

SYLLABUS

Course Description:

Water is vital to the functioning of both regional economies and ecosystems. Population growth, climate change, pollution, and persistent poverty all present challenges for the management of water resources. What are the major problems facing water resources in different regions of the Earth? What are the consequences for human health, food production, and ecosystems? What should be the roles of different management strategies such as dams, groundwater development, adaptive management, and integrated basin management? This course will include multiple ways of viewing water as a resource, including hydrology, ecology, socioeconomics, health, and politics. We will cover water resources modeling in urban and agricultural environments, climate change impacts on water resources, water in international economic development, and water quality.

The main questions of the course: What is a water crisis? Where do they occur? What causes them? How might they be solved? The overall goal of the course is to begin to construct a theory of water resources problems. Elements of this theory include hydrology, aquatic ecosystems and management paradigms that allow for learning in uncertain environmental systems.

LEARNING OBJECTIVES:

By the end of the course, students should be able to:

1. Define a water crisis, where they occur on Earth, and identify different discourses of water-human relationships.
2. Describe the major physical and sociopolitical processes regulating the distribution and management of water.
3. Perform calculations and quantitative analyses relevant to water resources evaluation and policy, including water balances, and critically assess mathematical models of water resources.
4. Critically assess statements about water resources problems.

ASSIGNMENTS:

Three homework/papers (30%)
- Homework is due by 5 pm on the due date.
- Late homework will be deducted 5% per day overdue (including weekends).
- No HW will be accepted more than one week after the due date.

Participation and discussion leader (15%)
- Half of this grade will be from participation throughout the semester, and half from being discussion leader.
- Each student will be responsible for leading two class discussions about a reading. Students will be evaluated on their preparation to lead the discussion. In some cases two students will co-lead.

Responses to readings (15%)
- The responses to readings are *very short* (1 paragraph) typed summaries of and responses to readings that identify 1) the main question posed, 2) the methods used to answer that question, 3) the main answer to the question and 4) the student's response to the reading. They are designed to focus reading and prepare students for the in-class discussions.
- There are a total of 14 weeks of reading. *The student may miss four for a total of 10 responses required for full credit.*
- Each week has more than one reading. The student chooses one reading for their response for the week.
- ** Responses are due on the day of the presentation. **
- ** NO LATE RESPONSES WILL BE ACCEPTED **

Research project (40%)

- Topic DUE NOVEMBER 11 (5%)
- Draft DUE NOVEMBER 24 (12%)
- Evaluation of another student's paper DUE DECEMBER 3 (3%)
- Final DUE DECEMBER 17 (20%)

The research project is designed for the student to go into greater depth on a topic of their choice. The student may meet with the professor in advance to discuss project ideas and to obtain feedback.
The paper must articulate a clear research question and address that question with evidence from a specific river basin and reference to scientific literature.
Length: 12-15 pages, double spaced, including figures, tables, and references.

GRADING will be the standard 93.0-100 A; 90.0-92.9 A-, 88.0-89.9 B+, 83.0-87.9 B; 80.0-82.9 B-, 78.0-79.9 C+, 73.0-77.9 C, 70.0-72.9 C-, 68.0-69.9 D+, etc., 0-59 F

WEEK	TOPIC	READINGS/ASSIGMT
OVERVIEW OF WATER RESOURCES		
Week 1 Sept 1-3	Introduction to water resources problems What is a water crisis? What causes them?	Selby Ch 1 Pearce Intro, Ch 1
Week 2 Sept 8-10	Global hydrologic cycle and time series How much water is there, and where is it? What defines a drought?	Oki Pearce Ch 3
WATER FOR LIFE: DO WE HAVE ENOUGH CLEAN WATER TO DRINK?		
Week 3 Sept 15-17	Water and health in developing countries	HDR Foreward, p. 1-7; HDR Ch 1, p. 27-44 Swyngedouw
Week 4 Sept 22-24	Urban water use and groundwater	Gleick, NRDC, Smith; **HW #1 DUE SEPT 25**
AGRICULTURAL WATER: DO WE HAVE ENOUGH FOR FOOD?		
Week 5 Sept 29-Oct1	Water balances and agriculture: ET Part I	Keller, Falkenmark,
Week 6 Oct 6-8	Water balances and agriculture: ET Part II	Pearce Ch 4, 26; HDR Wallace
Week 7 Oct 13-15	Hard Path: Dams	Pearce Ch 15 Gleick, WCD, Molle
Week 8 Oct 20-22	Soft path: Water productivity, water harvesting, virtual water	Pearce Ch 28, 33 Perry, Hoekstra, Allan **HW #2 DUE OCT 23**
Week 9 Oct 27-29	Integrated water management, Salt and pollution	Pearce Ch 22; Schoups; Cai, Biswas
Week 10 Nov 3-5	Allocation strategies and conflict	Dinar, Newlin, Wolf
Week 11 Nov 17-19	Climate change; snow	Pearce Ch 14 Vicuna; Barnett
ECOSYSTEMS, CLIMATE CHANGE, ADAPTIVE MANAGEMENT		
Week 12 Nov 10-12	Overview of ecosystems and water	Pearce Ch 9, 10 Postel, Ricciardi **PAPER TOPIC DUE NOV 13**
Week 13 Nov 24	Aquatic ecosystems	Postel, Poff **PAPER DRAFT DUE NOV 25**
Week 14 Dec 1-3	Uncertainty and adaptive management	Lee, Schmidt
Week 15 Dec 8-12	Ecosystem management: Colorado River	Glenn, Medellín-Azuara
HW #3 DUE DEC 13, FINAL PAPER DUE DEC 17		

READINGS:

Required:
Pearce, F. (2006), *When the Rivers Run Dry: Water--the Defining Crisis of the 21st Century*, Beacon Press, Boston.

Sandra Postel, Brian Richter, and The Nature Conservancy (2003), Rivers for Life: Managing Water For People And Nature, Island Press.

Week 1: Introduction

Pearce, Introduction and Chapter 1: The Human Sponge
Selby, J., 2003. Water, power and politics in the Middle East. I.B. Tauris, London, Chapter 1.

Week 2: The hydrological cycle and water accounting

Pearce, Chapter 3: Riding the water cycle
Oki, T. and Kanae, S., 2006. Global Hydrological Cycles and World Water Resources. Science, 313(5790): 1068-1072.

Week 3: Water and health

Human Development Report, p. 1-7
Human Development Report, p. 27-44
Swyngedouw, E. 1997. Power, nature, and the city. The conquest of water and the political ecology of urbanization in Guayaquil, Ecuador: 1880 - 1990. *Environment and Planning A* 29 (2):311-332.

Week 4: Urban water in California

Pearce, Ch 7
Gleick et al, 2003. Waste not, want not: The Potential for urban water conservation in California. p. 1-35
Smith, A., Lingas, E. and Rahman, M., 2000. Contamination of drinking-water by arsenic in Bangladesh: a public health emergency. Bulletin of The World Health Organization, 78: 1093-1103.
NRDC: California's contaminated groundwater.
Executive summary
Ch 1 (p 1-6): Hydrologic cycle
Ch 3 (Assessment of 5 pollutants): p 27-64

Recommended: Environmental Justice Coalition for Water: Thirsty for Justice. EJCW, Oakland, CA.

Week 5: Water in agriculture: Evapotranspiration Part I

Pearce Ch 4, 26
Keller, A., J. Keller, and D. Seckler. 1996. Integrated water resource systems: Theory and policy implications. Colombo, Sri Lanka: International Irrigation Management Institute.
Falkenmark, M. and Molden, D., 2008. Wake Up to Realities of River Basin Closure. International Journal of Water Resources Development, 24(2): 201-215.

Recommended:

Rodell, M., I. Velicogna, and J. S. Famiglietti. 2009. Satellite-based estimates of groundwater depletion in India. *Nature* 460 (7258):999-1002.

Week 6: Water in agriculture: ET Part II.

Human Development Report, p. 187-200 (Water productivity)

Wallace, J.S. and Batchelor, C.H., 1997. Managing water resources for crop production. Philosophical Transactions of Royal Society of London, series B, 352(937-947).

Recommended:

Batchelor, C.H., Rama Mohan Rao, M.S. and Manohar Rao, S., 2003. Watershed development: A solution to water shortages in semi-arid India or part of the problem? Land Use and Water Resources Research, 3: 1-10.

Week 7: Dams

Pearce, Ch 15

Gleick, P.H., 2003. Global Freshwater Resources: Soft-Path Solutions for the 21st Century. Science, 302(5650): 1524-1528.

World Commission on Dams. Executive Summary.

Molle, F.O., 2008. Why Enough Is Never Enough: The Societal Determinants of River Basin Closure. International Journal of Water Resources Development, 24(2): 217-226.

Week 8: Soft path: Water productivity, water harvesting, virtual water

Pearce, Ch 28, 33

Perry, C., Steduto, P., Allen, R. G., Burt, C. M., (2009). Increasing productivity in irrigated agriculture: Agronomic constraints and hydrological realities. Agric. Water Manage. 96 (11), 1517-1524.

Allan, J., 2007. Beyond the Watershed: Avoiding the Dangers of Hydro-Centricity and Informing Water Policy, Water Resources in the Middle East, pp. 33-39.

Hoekstra, A. Y., and P. Q. Hung. 2005. Globalisation of water resources: international virtual water flows in relation to crop trade. *Global Environmental Change Part A* 15 (1):45-56.

Week 9: Integrated water management; Salt and pollution

Pearce Ch 22

Biswas, A.K., 2008. Integrated water resources management: Is it working? Water Resources Development, 24(1): 5-22.

Schoups, G., J.W. Hopmans, C.A. Young, J.A. Vrugt, W.W. Wallender, K.K. Tanji, and S. Panday. 2005. Sustainability of irrigated agriculture in the San Joaquin Valley, California. Proceedings of the National Academy of Sciences of the United States of America 102:15352-15356.

Week 10: Water allocation strategies and conflict

Dinar, Ariel, Rosegrant, Mark W. and Meinzen-Dick, Ruth, "Water Allocation Mechanisms: Principles and Examples" (June 1997). World Bank Policy Research Working Paper No. 1779.

Newlin, B. D., M. W. Jenkins, J. R. Lund, and R. E. Howitt (2002), Southern California Water Markets: Potential and Limitations, *J. Water Resour. Plng. and Mgmt.*, *128*, 21-32.

Wolf, A. T. 1998. Conflict and cooperation along international waterways. *Water Policy* 1:251-265.

Recommended:

Cai, X., 2002. A framework for sustainability analysis in water resources management and application to the Syr Darya Basin. Water Resources Research, 38(6): doi 10.1029/2001WR000214.

Week 11: Overview of ecosystems and water

Pearce Ch 9, 10

Postel, Rivers for Life

Ricciardi, A. and Rasmussen, J.B., 1999. Extinction Rates of North American Freshwater Fauna. Conservation Biology, 13(5): 1220-1222.

Week 12: Climate change and snow

Pearce, Ch 14, p 123-127.

Vicuna, S. and Dracup, J., 2007. The evolution of climate change impact studies on hydrology and water resources in California. Climatic Change, 82(3): 327-350.

Barnett, T.P., J.C. Adam, and D.P. Lettenmaier. 2005. Potential impacts of a warming climate on water availability in snow-dominated regions. Nature 438:303-309.

Week 13: Aquatic ecosystems

Postel, Rivers for Life

Poff, N.L. et al., 2003. River Flows and Water Wars: Emerging Science for Environmental Decision Making. Frontiers in Ecology and the Environment, 1(6): 298-306.

Week 14: Uncertainty and adaptive management

Lee, K. (1993) Compass and Gyroscope: Integrating Science and Politics for the Environment. Island Press.

Schmidt, J.C., Webb, R.H., Valdez, R.A., Marzolf, R. and Stevens, L.E., 1998. Science and values in river restoration in the Grand Canyon. BioScience, 48(9): 735-747.

Week 15: Ecosystem management: Colorado River

Glenn, E.P., Zamora-Arroyo, F., Nagler, P.L., Briggs, M., Shaw, W. and Flessa, K., 2001. Ecology and conservation biology of the Colorado River Delta, Mexico. Journal of Arid Environments, 49(1): 5-15.

Medellín-Azuara, J., J. R. Lund, and R. E. Howitt (2007), Water Supply Analysis for Restoring the Colorado River Delta, Mexico, *Journal of Water Resources Planning and Management, ASCE*, *133*(5), 462-471.

Other cool articles/books (optional, for project ideas):

Cullather, N. (2002), Damming Afghanistan: Modernization in a Buffer State, *The Journal of American History*, *89*(2), 512-537.

Blomquist, William (1992), *Dividing the Waters: Governing Groundwater in Southern California*, ICS Press, San Francisco, CA, 415 pp.

Mukherji, A. (2006), Political ecology of groundwater: the contrasting case of water-abundant West Bengal and water-scarce Gujarat, India, *Hydrogeology Journal*, *14*(3), 392-406.

Environment and water resources

Richter, B.D., Warner, A.T., Meyer, J.L. and Lutz, K., 2006. A collaborative and adaptive process for developing environmental flow recommendations. River Research and Applications, 22(3): 297-318.

Water and economics: water markets California

Draper, A. J., M. W. Jenkins, K. W. Kirby, J. R. Lund, and R. E. Howitt (2003), Economic-Engineering Optimization for California Water Management, *J. Water Resour. Plng. and Mgmt.*, *129*, 155-164.

Pulido-Velazquez, M., M. W. Jenkins, and J. R. Lund (2004), Economic values for conjunctive use and water banking in southern California, *Water Resources Research*, *40*.

Modeling of water resources

Tilmant, A. and Kelman, R., 2007. A stochastic approach to analyze trade-offs and risks associated with large-scale water resources systems. Water Resources Research, 43.

Xu, C.-Y. and Singh, V.P., 2004. Review on regional water resources assessment models under stationary and changing climate. Water Resources Management, 18(6): 591-612.

Water, science and policy

Lankford, B., B. van Koppen, T. Franks, and H. Mahoo (2004), Entrenched views or insufficient science? Contested causes and solutions of water allocation; insights from the Great Ruaha River Basin, Tanzania, *Agricultural Water Management*, *69*(2), 135-153.

Climate change and water resources

Van Rheenen, N.T., Wood, A.W., Palmer, R.N. and Lettenmaier, D.P., 2004. Potential Implications of PCM Climate Change Scenarios for Sacramento–San Joaquin River Basin Hydrology and Water Resources. Climatic Change, 62(1): 257-281.

Miller, K. A., S. L. Rhodes, and L. J. Macdonnell (1997), WATER ALLOCATION IN A CHANGING CLIMATE: INSTITUTIONS AND ADAPTATION, *Climatic Change*, *35*(2), 157-177.

Christensen, N. S., A. W. Wood, N. Voisin, D. P. Lettenmaier, and R. N. Palmer (2004), The Effects of Climate Change on the Hydrology and Water Resources of the Colorado River Basin, *Climatic Change*, *62*(1), 337-363.

Water quality (ecological needs)

Tap water quality in San Diego:
http://www.ewg.org/tapwater/yourwater/system.php?pwsid=CA3710020

Paudel K, Zapata H, Susanto D (2005) An empirical test of environmental Kuznets curve for water pollution. Environmental and Resource Economics 31:325-348.

Allocation

Green, G. P., and J. R. Hamilton (2000), Water Allocation, Transfers and Conservation: Links between Policy and Hydrology, *International Journal of Water Resources Development*, *16*, 197-208.

Saleth, R. (1998), Water Markets in India: Economic and Institutional Aspects, in *Markets for Water*, edited, pp. 187-205.