SWS 4245/5246 Water Resource Sustainability

3 credits/Spring Semester

Course Motivation and Description

This course is about the global water crisis. The central issue is providing water for people and also ecosystems. Four key themes are maintained: hydrology, ecological protection, social justice, and economic opportunity.

Global demand for freshwater resources grows continuously, while at the same time there is increasing emphasis on preventing pollution and leaving enough water for natural ecosystem functions. These combined pressures define the need for sustainable water resource management. This course describes the effects of human impacts on hydrologic ecosystems (aquifers, watersheds, coastal zones, lakes, and wetlands) with quantitative measures of impacts and mitigation/attenuation efforts. Case studies from around the world will be used to illustrate both the detrimental effects of unsustainable resource utilization and the benefits of implementing sustainable resource management strategies.

This course is intended for graduate and advanced undergraduate students interested in the interactions between human civilization and hydrologic systems and should be of interest to agricultural and environmental scientists and engineers, and natural resource managers.

Instructor

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Office hours will be following class lecture or by appointment.

Course Format

Spring semester, three credits, two lectures and one discussion period per week.

Brief Outline

Topic	Weeks
Sustainability	1
Historical importance of water to humans	2,3
Equitable water allocation (meeting present and future minimum water needs)	3 -5
Water quality (groundwater and surface water)	6
Water transfers (including flow diversion and transboundary management)	7 - 10
Hydraulic infrastructure (including canals and dams)	11-12
Water institutions (including large-scale management)	13-15

"For the mind does not require filling like a bottle, but rather, like wood, it only requires kindling to create in it an impulse to think independently and an ardent desire for the truth."

Plutarch, c. 100 AD *Moralia*, *On Listening to Lectures* 48C (Loeb Classic Library 1.259)

Grading System

To reflect the different skills required for professional success, the final grade in this course is based on analytical reading/writing assignments, thoughtful and consistent participation, formal essay exams, and interesting individual and group projects.

	Points for grade	
Course components	**SWS4245**	**SWS5246**
Weekly writing assignments: 11 one-page assignments (4 points each)	44	44
Exam 1	100	100
Group project	52	37
Individual project [graduate students]	--	17
Exam 2	100	100
Class participation	37	35
Total points	**333**	**333**

1. There are two exams, each worth 30% of the total course grade. Exams are primarily essay questions linking concepts with specific information from case studies. Exam grades are historically highly correlated to class attendance. The exam dates and times are fixed FIRMLY, and no other accommodations can be made.
2. Late assignments will be penalized in proportion to the time since the due date, with zero credit after two weeks.
3. Class participation entails regular, on-time attendance and engagement.

Grade Scale

A ≥ 92 > A- ≥ 89 > B+ ≥ 86 > B ≥ 83 > B- ≥ 80 > C+ ≥ 77 > C ≥ 74 > C- ≥ 71 > D+ ≥ 68 > D ≥ 65 > D- ≥ 62 > E

Individual/Group Assignments

Your success as a professional will be based, in large part, on your ability to effectively communicate your ideas in both written and verbal forms. We all need practice to develop and improve these technical communication skills.

1. All students: Weekly reading assignments will require one-page written critical evaluations. Readings are available on the course e-learning web site accessible at https://lss.at.ufl.edu/. Readings are primarily academic research articles, supplemented with news analyses and commentaries, including selections from books. Writing assignments are due each Friday. Responses must be limited to one typed page that includes the following key components:
   - Brief description of the main points of the article,
   - Identify the fundamental concepts,
   - How does this information relate to previous information?

   A question or comment for in-class discussion must be identified at the end of the one-page response. You are likely to be *called upon in class* to share your comment. Typed assignments are due following the discussion period (Fridays).
2. All students: Group synthesis project about water resource sustainability. Deliverables: 1) 500-word initial vision statement (Thursday of Week 10), 2) Final report, plan, or creation oriented to an identified client, stakeholder, or audience, including a 15-minute pre-recorded presentation posted online (Sunday preceding Week 15).

3. Graduate students: Independently identify and visit at least one hydrologic/hydraulic feature related to concepts and topics discussed in class. Your visit must be photo-documented and posted on the class Google map (link on the course site) along with a description and discussion of how it relates to the course material. Note that you must be visible in your photo. Important: Credit can only be received through coordination with the teaching assistant. Check in advance to ensure suitability of your site before visiting. Due by the end of Week 13.

   [2015 map: https://www.google.com/maps/d/viewer?mid=z1XQjmjxTJaY.kE1td-h-10Qk]

Course Schedule

Week		Topic	Assignments
1		**1. Sustainability**	
	1/5	Water resources	1. Gleick
	1/7	Population, resources, and scarcity	2. Hardin; 3. Graedel and Klee
	1/8	*Getting Serious about Sustainability*	[1+2] or [1+3]
2		**2. Water History**	
	1/12	Human/environment dynamics	4. Lean
	1/14	Hydraulic societies	5. Hall; 6. Jacobsen and Adams
	1/15	*Timescales of Variability*	[5+6]
3		**3. Water Availability and Use**	
	1/19	World water resources	7. UN WWAP, 8. UN HDP
	1/21	Water use in the US and Globally	9 and 10: Poverty+water
	1/22	*Water for People: Human Costs*	[7.2+9] or [8+9]
4	1/26	What and where is groundwater?	11. Lightfoot
	1/28	Pumping	12. Steward
	1/29	*Shouts of the Present vs Whispers from the Future*	[11+12]
5	2/2	Water table decline	13. Famiglietti
	2/4	Global-scale perspective	14. Wada
	2/5	*Local Drivers, Global Consequences*	[13+14]
6		**4. Water Quality**	
	2/9	Contamination - Natural and anthropogenic	15. Pearce, 16. Smith
	2/11	Transport of contaminants	17. Cuyahoga, 18. Hogue
	2/12	*Societal Response to Resource Degradation*	[15+18] or [16+17]
7		**5. Water Transfer**	
	2/16	Surface water concepts	19. Transport
	2/18	Virtual water	20 and 21. Virtual water
	2/19	*Locations of Consumption vs Impacts*	[19+20] or [19+21]
8	2/23	Water redistribution	
	2/25	Flow diversions	
	2/26	**Exam 1**	
9		***No class – Spring Break***	
10	3/8	Local and global water diversions	22. Pearce
	3/10	Impacts on source regions	23. Dead Sea [**Vision statement]**
	3/11	*Restoration vs Rigidity Trap*	[22+23]
11		**6. Water Infrastructure**	
	3/15	Hydraulic structures - canals	24. USACE: Barge canal
	3/17	Hydraulic structures - dams	25. WCD: dams

	3/18	*Integrated Water Management*	[movie]
12	3/22	Dams and development	26. Yardley, 27. Elwha
	3/24	Floods	28. Rivera and Miller
	3/25	*Humans vs Ecosystems: The Hard Path*	[24+26] or [26+27]
13		**7. Water Institutions**	
	3/29	Legal frameworks and institutions (water rights)	29 and 30. Water law
	3/31	Competition for water	31. Water allocation in Australia
	4/1	*Management Scales*	[30+31]
14	4/5	Transboundary issues and disputes	32. Gulf hypoxia; 33. Barnaby
	4/7	Water for cities	34 and 35. Cities
	4/8	*Humans vs Humans: Cooperation vs Conflict*	[32+33] or [34+35]
15		**8. Synthesis**	**[Presentation]**
	4/12	Challenges: Locally unique vs globally transferable	
	4/14	Future trends	
	4/15	*Student Presentation Roundtable*	
16	4/19	**Exam 2**	

Assigned Readings

All readings are available on the course website. Numbered items are **<u>required</u>** readings, the others are suggested supplements.

1. Sustainability

Why is water important?
What is it we wish to sustain?
What are the typical patterns of resource exploitation?
How long will resources last?

1. Gleick, P.H., and Palaniappan, M., 2010. Peak water limits to freshwater withdrawal and use, *Proceedings of the National Academy of Sciences of the United States of America*, 107(25): 11155–11162.
2. Hardin, G., 1968. The tragedy of the commons, *Science*, 162(3859), 1243-1248.
3. Graedel, T. E. and Klee, R.J., 2002. Getting serious about sustainability, *Environ. Sci. Technol.*, 36 (4), 523-529.

   Bloom, D.E., 2011. 7 billion and counting, *Science*, 333(6042): 562-569, doi: 10.1126/science.1209290

   Borlaug, N., 1970. The Green Revolution, Peace, and Humanity, Nobel Prize Acceptance Speech, http://www.nobelprize.org/nobel_prizes/peace/laureates/1970/borlaug-lecture.html

2. Water History

On what time scales do Earth systems change?
How are water resources connected to societal development and decay?
How have human interventions in the hydrologic cycle evolved with time?

4. Lean, J.L. and D.H. Rind, 2009. How will Earth's surface temp*erature* change in future decades?, *Geophysical Research Letters*, 36, L15708, doi:10.1029/2009GL038932.

5. Hall, P., 1997. *Cities in Civilization,* Chapter 22: The Imperial Capital: Rome 50BC – AD 100, Pantheon, NY. (pp. 621-656)
6. Jacobsen, T. and R.M. Adams, 1958. Salt and silt in ancient Mesopo*tamian agriculture*, *Science*, 128 (3334), 1251-1258.

Mann, C., 2002. 1491. *The Atlantic Monthly*, 289(3), 41-53.

Bono P, and Boni C, 1996. Water supply of Rome in antiquity and today, *Environmental Geology*, 27(2): 126-134.

Ruddiman, W.F., 2005. How did humans first alter global climate? *Scientific American*, 3, 34-41.

Peterson, L.C., and G.H. Haug, 2005. Climate and the collapse of Maya civilization, *American Scientist*, 93(4): 322-329.

Aimers, J. and Hodell, D., 2011. Societal collapse: Drought and the Maya, *Nature*, 479: 44–45.

Tainter, J.A., 2006. Archaeology of overshoot and collapse, *Annu. Rev. Anthropol.*, 35, 59-74.

Kummu M., 2009. Water management in Angkor: Human impacts on hydrology and sediment transportation, *Journal of Environmental Management*, 90(3): 1413-1421.

Wright KR, Witt GD, and Zegarra AV, 1997. Hydrogeology and paleohydrology of ancient Machu Picchu, *Ground Water*, 35(4): 660-666.

3. Water Availability and Use

Where is the world's fresh water?
When is the water there?
How are humans using freshwater?
Is everybody getting enough water?
Who uses groundwater?
Where is groundwater?
What happens when groundwater is pumped?

7. World Water Assessment Programme, 2009. *The United Nations World Water Development Report 3: Water in a Changing World*. Paris: UNESCO. http://www.unesco.org/water/wwap/wwdr/wwdr3/
   7.1. Ch. 10, Vorosmarty et al., "The Earth's natural water cycles", **[pp. 166-180]**
   7.2. Ch. 7, Connor et al., "Evolution of water use", **[pp. 96-126]**
8. United Nations Human Development Program, 2006. *Beyond Scarcity: Power, Poverty and the Global Water Crisis*, UNDP: NY. http://hdr.undp.org/hdr2006/ **[pp. 27-54]**
9. Developing-world hydraulic cycle
   9.1. Gifford, R., 2011. "Phnom Penh's Feat: Getting Clean Tap Water Flowing", National Public Radio, 2 June, http://www.npr.org/2011/06/02/136394058/phnom-penhs-feat-getting-clean-tap-water-flowing [hear the story with interviews]
   9.2. Narain, S., 2012. Sanitation for all, *Nature*, 486: 185.
10. Wutich A, and Ragsdale K, 2008. Water insecurity and emotional distress: Coping with supply, access, and seasonal variability of water in a Bolivian squatter settlement, *Social Science & Medicine*, 67(12): 2116-2125.
11. Lightfoot, D.R., 1996, Syrian qanat Romani: history, ecology, abandonment, *J. Arid Environments*, 33, 321-336.
12. Steward, D.R., et al., 2013. Tapping unsustainable groundwater stores for agricultural production in the High Plains Aquifer of Kansas, projections to 2110, *Proceedings of the National Academy of Sciences of the United States of America*, 110(37): E3477-E3486.

13. Famiglietti, J.S., 2011. Satellites measure recent rates of groundwater depletion in California's Central Valley, *Geophysical Research Letters*, 38, L03403, doi:10.1029/2010GL046442.
14. Wada et al., 2012. Past and future contribution of global groundwater depletion to sea-level rise, *Geophysical Research Letters,* 39, L09402.

Maupin, M.A., Kenny, J.F., Hutson, S.S., Lovelace, J.K., Barber, N.L., and Linsey, K.S., 2014, Estimated use of water in the United States in 2010: U.S. Geological Survey Circular 1405, 56 p., http://dx.doi.org/10.3133/cir1405.

"The worth of water", *The Economist*, 24 May 2011. [Phnom Penh water supply]

FDEP, 2011. DRAFT Restoration Plan for the Rainbow Springs and River. **[pp. 1-34]**

Purdum, E.D., 2002. *Florida Waters: A Water Resources Manual from Florida's Water Management Districts*, http://www.srwmd.state.fl.us/resources/florida_waters.pdf

Alley, W.M., Reilly, T.E., and O.L. Franke, 1999, *Sustainability of Ground-Water Resources*. United States Geological Survey Circular 1186, USGS: Denver, CO. **[pp. 1-19]** http://water.usgs.gov/pubs/circ/circ1186

Shah, T., Deb Roy, A., Qureshi, A.S., and J. Wang, 2003. Sustaining Asia's groundwater boom: An overview of issues and evidence, *Natural Resources Forum*, 27: 130–141.

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

Galloway, D., Jones, D.R., and S.E. Ingebritsen, 1999. *Land Subsidence in the United States*, United States Geological Survey Circular 1182, USGS: Denver, CO. http://water.usgs.gov/pubs/circ/circ1182 **[pp. 7-34]**

4. Water quality

How does water get contaminated?
What are the effects of contamination?
What are likely trajectories of societal response?

15. Pearce, F., 2004. *Keepers of the Spring*, Island Press. **pp. 89-107 [Arsenic in Bangladesh]**
16. Smith RP, 2009. The blue baby syndromes, *American Scientist*, 97(2): 94-96.
17. Cuyahoga River
    - 17.1. Maag, C., 2009. From the ashes of '69, a river reborn, *New York Times*, 21 June.
    - 17.2. Adler, J.H., 2004. Smoking out the Cuyahoga fire fable, *National Review*, 22 June.
18. Hogue, C., 2003. Rocket-fueled River, *Chemical & Engineering News*, August 18, v. 81(33), pp. 37-46. http://pubs.acs.org/cen/coverstory/8133/8133perchlorates.html

Neumann RB, Ashfaque KN, Badruzzaman ABM, et al., 2010. Anthropogenic influences on groundwater arsenic concentrations in Bangladesh, *Nature Geoscience*, 3(1): 46-52.

Powlson DS, Addisott TM, Benjamin N, et al., 2008. When does nitrate become a risk for humans?, *Journal of Environmental Quality*, 37(2): 291-295.

Thomsen, R. and L. Thorling, 2003. Use of protection zones and land management restore contaminated groundwater in Denmark, *Eos* Tran, 84 (7), 18 February.

Committee on Environment and Natural Resources, 2010. *Scientific Assessment of Hypoxia in U.S. Coastal Waters*. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, DC. http://www.whitehouse.gov/administration/eop/ostp/nstc/oceans [pp. 1-5, 11-24]

World Health Organization, 2014. Cholera, 2013. *Weekly Epidemiological Record*, 89(31): 345–356, 1 August, http://www.who.int/wer/2014/wer8931/en/

5. Water Transfer

Who uses surface water?
Where are the important watersheds?
How is water redistributed, both physically and virtually?

19. Long-distance water transport
    19.1. Kaiman, J., 2014. China's water diversion project starts to flow to Beijing, *The Guardian*, 12 December, http://gu.com/p/445qb/sbl
    19.2. Rogers, P., 2014. California drought: State Water Project will deliver no water this summer, *San Jose Mercury News*, 31 January, http://www.mercurynews.com/science/ci_25036886/california-drought-state-water-project-will-deliver-no
20. Chapagain, A.K, and Hoekstra, A.Y., 2008. The global component of freshwater demand and supply: An assessment of virtual water flows between nations as a result of trade in agricultural and industrial products, *Water International*, 33(1): 19–32.
21. Dalin, C. et al., 2012. Evolution of the global virtual water trade network, *Proceedings of the National Academy of Sciences of the United States of America*, 109(16): 5989-5994.
22. Pearce, F., 2004. *Keepers of the Spring*, Island Press. **pp. 109-122 [Aral Sea]**
23. Dead Sea
    23.1. Glausiusz, J., 2010. New life for the Dead Sea?, *Nature*, 464: 1118-1120, 22 April.
    23.2. Willner, S., 2014. Rehabilitating the changed environment from the Hula Valley to the Dead Sea, *The Jerusalem Post*, 6 November, http://www.jpost.com/landedpages/printarticle.aspx?id=380842

    Lasi and Shuman, 1996. *Orange Creek Basin Surface Water Management Plan*, St. Johns River Water Management District [Hydrology excerpts: pp. 17-36]; also see the basin overview here: http://www.sjrwmd.com/orangecreek/

    Folger, T., 2008. Requiem for a river, *OnEarth Magazine*, 29 February. [Colorado River] http://www.onearth.org/article/requiem-for-a-river

    Vollmann, W., 2002. Where the ghost bird sings by the poison springs, *Outside Magazine*, February. [Salton Sea] http://outsideonline.com/environment/200202/200202where_the_ghost.html

6. Infrastructure: Dams, Canals, Flood Protection

What is the purpose of hydraulic structures?
Where are hydraulic structures important?
What is the future of hydraulic structures?

24. Godfrey, M.C., and Catton, T., 2011. Ch. 5 Flexing the Environmental Muscle: The Cross-Florida Barge Canal, the Everglades Jetport, and Big Cypress Swamp, In *River of Interests: Water Management in South Florida and the Everglades, 1948-2010,* US Army Corps of Engineers, Washington DC **[pp. 69-89]**
25. World Commission on Dams, 2000. *Dams and Development: A New Framework for Decision-making*, the Report of the World Commission on Dams (WCD). http://www.dams.org/report/ **[pp. 11-23, 65-69, 78-81]**
26. Yardley, J., 2007. Chinese Dam Projects Criticized for Human Costs, (Part IV in the 'Choking on Growth' series), *New York Times*, 28 September.

http://www.nytimes.com/interactive/2007/11/19/world/asia/choking_on_growth_4.html

27. Eilperin, J., 2011. Elwha Dam removal illustrates growing movement, *The Washington Post*, 16 September.
28. Rivera, J.D., and D.S. Miller, 2007. Continually neglected: Situating natural disasters in the African American experience, *Journal of Black Studies*, 37(4): 502-522.

McPhee, J., 1987. The Control of Nature: Atchafalaya, *The New Yorker*, 23 February 1987.

Rogers JD, 2008. Development of the New Orleans flood protection system prior to Hurricane Katrina, *Journal of Geotechnical and Geoenvironmental Engineering*, 134(5): 602-617.

7. Water Institutions

How is water allocated?
How are transboundary waters managed?
How do dynamic power geometries affect water allocation?

29. Glennon, R., 2002. Water Follies: Groundwater Pumping and the Fate of America's Fresh Waters, Island Press. **[pp. 13-34]**
30. Munson, A.B., Delfino, J.J., and Leeper, D.A., 2005. Determining minimum flows and levels: The Florida experience, *Journal of the American Water Resources Association*, 41(1): 1-10.
31. Murray-Darling Basin (Australia)
    - 31.1. 26 April 2007: "The big dry", *The Economist*.
    - 31.2. 7 May 2009: "In need of a miracle", *The Economist*.
    - 31.3. 24 April 2010: "The drought ends, the shouting starts", *The Economist*.
    - 31.4. 9 December 2010: "River chief resigns: Plan to save Australian river system runs aground", *Nature*, 468: 744, doi:10.1038/468744a.
    - 31.5. 28 November 2011: "Mixed response to Murray-Darling plan", ABC News [Australian Broadcasting Corporation]. http://www.abc.net.au/news/2011-11-28/draft-basin-plan-released/3698064 [Videos included on web link]
32. Rabotyagova, S.S., et al., 2014. Cost-effective targeting of conservation investments to reduce the northern Gulf of Mexico hypoxic zone, *Proceedings of the National Academy of Sciences of the United States of America*, 111(52): 18530–18535.
33. Barnaby, W., 2009. Do nations go to war over water?, *Nature*, 458: 282-283.
34. Power, M., 2013. Cry us a river, *OnEarth*, Spring 2013, pp. 32-39. http://issuu.com/onearth/docs/onearth_spr13# [Chicago River]
35. Pires, M, 2004. Watershed protection for a world city: the case of New York, *Land Use Policy*, 21(2): 161-175.

Yoffe, A. et al., 2003. Conflict and cooperation over international freshwater resources: Indicators of basins at risk, *Journal of the American Water Resources Association*, 39(5):1109-1126.

South Asia's water: Unquenchable thirst, *The Economist*, 19 November 2011.

Revenga, C., 1998. *Watersheds of the World: Ecological Value and Vulnerability*. Worldwatch Institute: Washington, D.C. http://wri.igc.org/watersheds

US Defense Intelligence Agency, 2012. *Global Water Security*, Intelligence Community Assessment ICA 2012-08, 2 February.