SUMA K4145 The Science of Sustainable Water

Instructor: Wade McGillis

1. Course Description

The sustainability of water resources is a critical issue facing society over the coming decades. Water resources are affected by changes not only in climate but also in population, economic growth, technological change, and other socioeconomic factors. In addition, they serve a dual purpose; water resources are critical to both human society and natural ecosystems. The objective of this course is to first provide students with a fundamental understanding of key hydrological processes. Students will then use this understanding to explore various sustainable strategies for integrated water resources management. Case studies will be highlighted throughout the course to illustrate real world, practical challenges faced by water managers. Students will be asked to think critically and to use basic quantitative and management skills to answer questions related to sustainable water development. Considering the importance of water to society the understanding that students obtain from this course will be an essential part of their training in sustainable management.

This course satisfies the program's physical dimensions requirement. Students are able to identify about the connections between environmental inputs (i.e. natural resources) and outputs (i.e. energy), and their effects on the natural environment. The emphasis in this requirement will be on assessing the environmental impacts from organizational activities. The planning, design or architecture courses give students a foundation in planning, design and spatial issues. This is particularly important, as many sustainability initiatives concern land use, buildings and other physical entities.

2. Course Objectives

Students are expected to understand the key components of the water cycle and their relevance for water--resource sustainability, including precipitation, evapotranspiration, groundwater, and surface water. Students are also expected to become familiar with the fundamental principle of mass conservation, as it is a basic concept needed to manage water resources sustainably.

Sustainability issues in water management will be explored for various regions, including those in both developing and developed countries, and at various scales (local to global). Students should then be prepared to apply strategies for water--resource management to specific cases studies recognizing socioeconomic and scale issues.

3. Course Content

1. 1/24 Introduction
   Class Plan
   1. Course Description
   2. Course Objectives
   3. Course Content
   4. Instruction and Method of Evaluation

   Assignments Due
   None

2. 1/31 Overview of water sustainability issues

Class Plan
Class topics:
Local to global issues; Water resources and society (past to present); Development issues:

rural/suburban/urban; Sectoral issues: domestic, agricultural, industrial; Define sustainability and hydrologic ecosystem services; Spatiotemporal scaling issues in water resources.

Assignments Due
Readings

Required Readings:
Pearce, Chapter I
Vörösmarty (2000) paper
Mays, Chapter 1

3. 2/7 Basics of the hydrologic cycle I (Assign HW1)

Class Plan
Mass-balance concept Precipitation

Required Readings:
Pearce (2006) - Chapter II (we mine our children's water)
Bonan, Ecological Climatology (2002) - Chapter 5 (note: figures are in a separate file)

Recommended Readings:
Chow et al (1988) - chapter 1 and 3

4. 2/14 Basics of the hydrologic cycle II (Submit project team and topic)

Class Plan
Runoff
Surface water (rivers and deltas)

Required Readings:
Pearce, Chapter III - the wet places die

5. 2/21 Basics of the hydrologic cycle III

Class Plan
Floods
Soil moisture
Evapotranspiration
Groundwater
Infiltration

Assignments Due
Topic, group members, and paragraph for Term project
Homework #1

Required Readings:
Pearce Chapter IV...floods may not be far behind; also, review water cycle related readings (i.e. Bonan)

6. 2/28 Human interventions in the hydrologic cycle (Assign HW2)

Class Plan
Evapotranspiration
Dams and reservoirs

Required Readings:
Pearce (2006) - Chapter V, engineers pour concrete

US water withdrawal projections
Mexico Water Management

7. 3/7 Water Management I (Submit project outline)

Class Plan
Characteristics of streamflow
Storage and design
Reliability/sampling approaches
Agricultural/Municipal/Industrial water use

Required Readings:
Pearce (2006) - When the rivers run dry ... men go to war over water (VI)
US water withdrawal projections
Mexico Water Management

8. 3/14 Water Management II

Assignments Due
Deadline HW 2 - Friday March 23rd at 5pm

Required Readings:
Pearce (2006) - When the rivers run dry ... civilizations fall
Loucks (2005) - Chapter 1.3 - 1.6

Recommended Readings:
Drinking Water quality and health
Water quality
Mexico City (2010) - Climate Change

9. 3/21 Spring Break

10. 3/28 Water Resource Sustainability (Assign HW3)

Class Plan
AN ECOLOGICAL-ECONOMICS VIEW OF SUSTAINABILITY
Virtual water (TOWARD SUSTAINABLE MANAGEMENT OF WATER RESOURCES)

Required Readings:
Pearce (2006) - When the Rivers Run Dry .. we go looking for new water
Mays (2007) (see document attached below) - - Chapter 3, pp 56 - 69.

Recommended Readings:
Brauman et al (2007) - Hydrologic ecosystem services

11. 4/4 Water pricing and trade

Class Plan
Virtual water trade and transfer
Rainwater harvesting
Water pricing

Assignments Due
Specific, refined research question and outline due for term project.

Required Readings:
Pearce (2006) - When the Rivers Run Dry .. we try to catch the rain
Molle (2009) - Water scarcity, prices and quotas: a review of evidence on irrigation volumetric pricing
Porter (2008) - Rainwater harvesting

Recommended Readings:
Konar et al (2011) - Water for food: The global virtual water trade network
Waterfall (2004) - Harvesting rainwater for landscape use

12. 4/11 Water and its climate connections

Class Plan
Agricultural water pricing (continue)
Climate and the water management link
Basics of global-scale circulation; Natural Climate Variability; ENSO and hydrologic extremes

Assignments Due
Home-work #3 due
Take-home exam will be distributed at the end of class.
Take-home exam due electronically April 24th at 5pm

Required Readings:
Pearce (2006) - When the Rivers Run Dry .. we go with the flow
Molle (2009), if you have not read it yet
ENSO Basics

Recommended Readings:
Molle (2009), if you have not read it yet
Cayan (1999) - ENSO and Hydrologic Extremes in the Western United States

13. 4/18 Water and climate-resilient development

Class Plan
Climate-resilient development
Linking climate scenarios and water management
Understanding climate-scenario development for water-resource applications
Special topic: Hydraulic Fracturing

Assignments Due
Take-home exam due

Required Readings:
Puma and Gold (2011) Formulating Climate Change Scenarios - This guidebook builds on a large range of UNDP's ongoing initiatives to support adaptation to climate change. This series is intended to empower decision makers to take action, and to prepare their territories to adapt, and hopefully thrive, under changing climatic conditions.
Gleick (2011) - Meeting Basic Human Needs for Water Remains Huge Challenge

14. 5/2 Project Presentations (Final Day of Class)

4. Instruction and Method of Evaluation

Course Requirements -Assignments
The major assignments of the course will include three homework assignments, an exam, and a final project (with a presentation). The Homework assignments and exam are both designed to reinforce the

basic concepts presented in class and to ensure that students master the key concepts. The objective of the final project is to have student apply the concepts that they explore in class to a real--world case, where sustainable management of water resources is needed.Evaluation of the homework, exam, and project will be based on how well the students demonstrate their knowledge of the water--management issues covered in the course.

Evaluation/Grading
The relative contribution of each of the assignments to a student's total grade for the course is as follows:
Three Homework assignments = 30%
Take--home Exam = 35%
Final Project and presentation = 35%

The grading will be based on accuracy, completeness, and how effectively the students have incorporated course ideas into their answers. The Homework assignments will be graded on a letter grade scale from F to A+.

The Exam will be a take--home style exam. Students are permitted to use their notes, course readings, and the Internet to answer questions. However, they may not discuss questions and answers with others. The take--home exam will consist of quantitative exercises as well as essays related to water sustainability. The Exam will be graded on a numeric scale from 0 to 100.

The final project should consist of an 8- to 10--page report (double spaced) on a case study related to sustainable management of water resources.

The project also includes a 10--minute presentation during the final class. Possible topics will be presented in class. Students are free to propose alternative case study projects, but these need to be discussed with and approved by the Professor. The final project should include analyses and discussions that build on ideas discussed in the course. The final project (including the presentation) will be graded on a letter grade scale from F to A+. The final course grade will be computed using a weighted average of the homework, exam, and final project scores and then scaled into a letter grade scale from F to A+.

Policies and Expectations Attendance, Late Assignments, and Missed Exam
Students are expected to attend and participate in class. Assignments should be submitted in a timely manner, so that students will be able to understand and benefit from course content.
Late assignments will be penalized 10% per day of lateness. A missed exam will result in no credit for the exam. Extenuating circumstances should be brought to the attention of the Professor and will be handled on a case--by--case basis.

5. Resources and Software Packages

Courseworks will be used for communication of assignments, exams, course material, and other information throughout the course. Students should be familiar with Microsoft Excel (but may contact the Professor for additional direction). The Columbia University Libraries will be primary resources for course material.

6. Readings and Textbooks

All readings will be posted on Courseworks in the 'Syllabus' section. Each session will have its own page, so please be sure to check there before each class for relevant readings and other announcements. Students should read this material before each class (i.e. The readings should be done by start of lecture that it is associated with).

Text For purchase:

1. When the rivers run dry: water, the defining crisis of the twenty-- first century, Fred Pearce. 2006.

2. Introduction to Physical Hydrology, Martin Hendriks. 2010.

Available Electronically through Columbia Library
1. Water Resources Sustainability, L. W. Mays,
http://clio.cul.columbia.edu:7018/vwebv/holdingsInfo?bibId=7330667;
2. Applied hydrology, Ven Te Chow, David R. Maidment, Larry W. Mays.
http://www.columbia.edu/cgi--bin/cul/resolve?clio6099600
3. Water Resources Systems Planning And Management, D.P. Loucks,
http://ecommons.library.cornell.edu/handle/1813/2804

Supplemental reading will be provided drawing from the scientific and policy literature.

References

• Aeschbacher, J, et al (2005), River water shortage in a highland-lowland system: A Case study of the impacts of water abstraction in the Mount Kenya region.
• Brauman, KA et al. (2007). The nature and value of ecosystem services: an overview highlighting hydrologic services. Annu. Rev. Environ Resour.32:67-98
• Brown, TC (2000). Projecting US freshwater withdrawals. Journal of Water Resources Research.
• Cane, M. The ENSO Mechanism.
• Chow, VT et al. (1988). Applied hydrology.
• Dinar, A. Water allocation mechanisms-- principles and examples.
• Downs, TJ et al (2000), Sustainability of least cost policies for meeting Mexico City's future water demand. Water Resources Research, vol. 36, no. 8, pages2321-2339.
• Konar, M.et al (2011), Water for food: The global virtual water trade network.
• Hoekstra, AY, and Chapagain, AK (2007) Water footprints of nations: Water use by people as a function of their consumption pattern, Water Resource Management 21:35-48.
• Lall, U. and Jain, S. (2001) Floods in a changing climate: Does the past represent the future? Water Resources Research, vol. 37, no. 812, Pages 3193-3205.
• Loucks, DP (2005). Water Resources Systems Planning and Management.
• Masters, GM(1991). Introduction To environmental engineering and science.
• Mays, L (2007). Water Resources sustainability.
• MacLeod, M, Smith, E (2003) Economic principles for sound water planning: An introduction for regional water planning groups in Texas. Environmental Defense.
• Pearce, F (2006). When the rivers run dry: water, the defining crisis of the twenty-- first century.
• SEI (2009) Rainwater harvesting: a lifeline for human well--being: a report prepared for UNEP by Stockholm Environment Institute.
• Vörösmarty, CJ et al (2000). Global water resources: vulnerability from climate change and population growth. Science 289,284.
• Vörösmarty, CJ and Sahagian D (2000). Anthropogenic Disturbance of the terrestrial water cycle, Vol. 50 No.,BioScience.
• Vörösmarty, CJ Et al.(2010). Global Threats to human water security and river biodiversity. Nature.

7. Policies

Academic Integrity and Community Standards
The School of Continuing Education does not tolerate cheating and/or plagiarism in any form. Those students who violate the Code of Academic & Professional Conduct will be subject to the Dean's Disciplinary Procedures. Students Are required to comply with the School's policies related to Academic Integrity and Community Standards (details can be found at http://ce.columbia.edu/node/217).

An excerpt is as follows:

"Columbia University expects that its students will act with honesty and propriety at all times and will respect the rights of others. It is fundamental University Policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University Community is unacceptable and will be dealt with severely."
Appendix B of this syllabus contains the University's disability statement.