University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

# Sustainability Science: Quantitative and system approach

3 credits

**MEES 622**
Spring 2020

## Course Objectives / Overview

In 2015, all 193 member countries of United Nations have ratified the Sustainable Development Goals, demonstrating their ambitions towards sustainability. Sustainability, defined as "sustainable development" by the United Nations World Commission on Environment and Development in 1987, "meets the needs of the present without compromising the ability of future generations to meet their own needs". However, what exactly sustainability means for a country as well as individuals, how it could be achieved, and how progress could be assessed remain elusive. Although sustainability encompasses topics beyond the natural sciences, the environmental sciences can offer tools to help define and assess sustainability. Indeed, forestry and fisheries management have a long history of developing sustainable yield concepts, with varying historical success in implementation. Modern sustainability science goes beyond single-resource management and integrates biophysical and socio-economic considerations of sustainability. This course is designed to help provide students with a historical background, critical thinking approaches, and analytical tools to address sustainability from a scientific perspective by:

1) reviewing and discussing basic concepts, past and active debates, and cutting-edge ideas;
2) learning and applying system and quantitative analysis skills;
3) developing a case study for a country/topic of interest in a highly-diversified group.

## Expected Learning Outcomes

Through this class, students are expected to

- gain an in-depth understanding of sustainability issues.
- implement basic quantitative methods for modeling and analyzing a system.
- develop a research project, individually or in a small group, on a sustainability issue of interest and provide quantitative analysis to identify challenges and opportunities.

## Course Assessment / Grading

| **Evaluation** | **100%** |
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| Class Participation | 15% |
| Discussion Leader | 15% |
| Mid-term | 20% |
| Project presentation | 20% |


**INSTRUCTOR DETAILS:**

**Xin Zhang**
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**CLASS MEETING DETAILS:**

**Dates:**
**Times:**
**Originating Site:**
**IVN bridge number:**
(*******)
**Phone call in number:**
(***)
**Room phone number:**
(*****)

**CURRICULUM FULLFILMENT:**
MEES *** fulfills a *** (PD, ISG, elective, etc) MEES requirement.

**Prerequisites**
N/A
Knowledge of one programming language (e.g., R, Matlab) is preferred

**Teaching Assistant**
TBD

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| Term paper | 30% | |

## Tentative Weekly Course Schedule

| Date | Course contents |
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| **Week 1** | **Course overview (contents, organization, Q&A, etc.)** |
| | *Environmental Dimension* |
| **Week 2** | **Lecture**<br>• An historical perspective from Malthusian warnings of impending famine to current estimates of planetary boundaries |
| | **Reading & Discussion**<br>• What is Sustainability? |
| **Week 3** | **Lecture**<br>• An overview of human disturbances to biogeochemical cycles (C, N, P, $H_2O$), to alterations of biophysical properties of the earth system (land surface, net primary productivity, water, climate change, etc.), and to biodiversity |
| | **Reading & Discussion:**<br>• Planetary Boundaries (Rockstrom et al., 2009; Steffen et al., 2015); You Can't Eat GNP excerpts (Davidson, 2000) |
| | *Socioeconomic Dimension* |
| **Week 4** | **Lecture**<br>• Integration of concepts of neoclassical and ecological economics with ecology, such as fungibility of resources, discounting future costs and benefits, valuation of unpriced resources, etc. |
| | **Reading & Discussion**<br>• Is there an Environmental Kuznets Curve? (Grossman and Krueger, 1995; Dinda, 2004) |
| **Week 5** | **Lecture**<br>• Social welfare: nutrition, education, equality, food security |
| | **Reading & Discussion**<br>• The impacts of international trade on sustainability (Liu et al., 2013; Bailey and Wellesley, 2017)<br>• The trade-offs in revitalizing world rural community (Liu and Li, 2017) |
| | *System Thinking (Case studies in sustainability)* |
| **Week 6** | **Lecture (CASE Study)**<br>• Assessing sustainability in agricultural production with a Sustainable Agricultural Matrix |
| | **Data Exploration: Indicator systems**<br>• SDG Index and dashboard, Environmental Performance Index, Sustainable Agriculture Matrix |
| **Week 7** | **Lecture (Sustainable Fisheries and a CASE Study; Wilberg guest lecture)**<br>• A brief history of sustainable fisheries efforts<br>• A recent case of fishery management using quantitative modeling approach |
| | **Brain storm course project ideas and organize research groups** |

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| | **Data Exploration**<br>• Project can be developed by individual students or a student group (no more than 4 members) |
| **Week 8** | **Lecture (Renewable Energy: A CASE Study; Peng guest lecture)**<br>• A case of Energy-Water Nexus (e.g., a guest lecture on quantifying energy source trade-offs; by Wei Peng, Harvard University) |
| | **Mid-term exam** |
| | *System Solutions* |
| **Week 9** | **Lecture**<br>• Basics and examples to describe, conceptualize, analyze, and optimize a system |
| | **Reading & Discussion**<br>• How to assess the tradeoffs among environmental, economic, and social dimensions of sustainability?<br>• How to make policy in the context of complex trade-offs? |
| **Week10** | **Lecture**<br>• Model and optimize a system with multiple stakeholders (e.g. Agent Based Model) |
| | **Reading & Discussion**<br>• How to assess and model the resilience of a system? (e.g., Network analysis, model-based approach)<br>• What are the systemic risks in global agricultural system? |
| **Week11** | **Lecture**<br>• A review of major international agreements for sustainability (e.g., SDGs, MDGs, Montreal Protocol, The Paris Agreement, …) |
| | **Reading & Discussion**<br>• Lessons and experiences learned from the major international agreements<br>• The role of governments and international organizations in Sustainable Development |
| **Week12** | **Lecture**<br>• Technology innovation and sustainable development (major innovations in renewable energy, agriculture, fisheries and other fields; how technology may help with tunneling through the Environmental Kuznets Curve; what is the backfire effect, unintended consequences, and the efficiency paradox?) |
| | **Reading & Discussion**<br>• The role of academics and industry in sustainable development |
| **Week13** | **Lecture**<br>• Education and communication for sustainable development |
| | **Reading & Discussion**<br>• The role of individuals in Sustainable Development (e.g. dietary change, behavioral change, …) |
| **Week14** | **Project presentation and discussion** |
| | **Project presentation and discussion** |
| **Week15** | **Project presentation and discussion** |
| | **Project presentation and discussion** |

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| **Week16** | **(Exam week: no final exam)** |
| **Week17** | **Deadline for submitting term paper** |

## Required textbooks, reading and/or software or computer needs

There is no required text book for this course. Here is a list of suggested reading. Reading materials required by each class will be posted to the student before the class.

*Books*

- Pursuing Sustainability: A guide to the science and practice. by Pamela Matson, William C. Clark, Krister Andersson.
- The Age of Sustainable Development. by Jeffrey Sachs
- You can't eat GNP: Economics as if ecology mattered. by Eric A. Davidson
- Biogeochemistry: An analysis of global change. by William H. Schlesinger
- The Big Ratchet: How humanity thrives in the face of natural crisis. by Ruth DeFries

*Journal articles (Here are several examples of journal articles will be reviewed in this class)*

Liu, Jianguo, et al. "Framing sustainability in a telecoupled world." Ecology and Society 18.2 (2013).

Liu, Yansui, and Yuheng Li. "Revitalize the world's countryside." Nature 548.7667 (2017): 275.

Bailey, Rob, and Laura Wellesley. "Chokepoints and Vulnerabilities in Global Food Trade." London: Chatham House (2017).

Dinda, S., 2004. Environmental Kuznets Curve hypothesis: A survey. Ecol Econ, 49(4): 431-455.

Grossman, G.M. and Krueger, A.B., 1995. Economic-Growth and the Environment. Quarterly Journal of Economics, 110(2): 353-377.

Rockstrom, J. et al., 2009. A safe operating space for humanity. Nature, 461(7263): 472-475.

Steffen, W. et al., 2015. Planetary boundaries: Guiding human development on a changing planet. Science: 1259855.

Zhang, X. et al., 2015a. Managing nitrogen for sustainable development. Nature, 528(7580): 51-59.

Zhang, X., Mauzerall, D.L., Davidson, E.A., Kanter, D.R. and Cai, R., 2015b. The economic and environmental consequences of implementing nitrogen-efficient technologies and management practices in agriculture. J Environ Qual, 44(2): 312-324.

## Course Communication

[You should specify how you will send information to students (e.g. MOODLE announcement) and how you want students to contact you (e.g. MOODLE, email, Google Drive) to discuss questions or other information.]

We will send information to students through email and share files via Google Drive. Students can contact us via email or phone to discuss questions or other information.

## Resources

[Course website: www.moodle.com/xxxxx]

## Campus Policies

The University of Maryland Center for Environmental Science has drafted and approved of various academic and research-related policies by which all students and faculty must abide.

Please see especially Policy III-1.00: Policy on Faculty, Student and Institutional Rights and Responsibilities for Academic Integrity.

## Course-Specific Policies and Expectations

[Separate from the campus-wide policies linked earlier, you may want to outline any additional course policies of which students need to be aware. Also include late work policy, etc.]