TEXAS A&M UNIVERSITY

Course Syllabus

Course Information

Course Number:	GEOG 467/667
Course Title:	DYNAMIC MODELING OF EARTH AND ENVIRONMENTAL SYSTEMS
Section:	501/601
Credit Hours:	4
Online Course Info:	https://canvas.tamu.edu/
Time (Lectures):	TR 11:10 am – 12:25 pm
Location (Lectures):	OMB 103
Time (Labs):	T 2:20 pm – 4:10 pm
Location (Labs):	CSA 307

Instructor Details

Instructor:	Dr. Burak Güneralp
Office:	O&M 804
Phone:	(979) 845-6422
E-Mail:	bguneralp@tamu.edu
Office Hours:	TR 12:50 pm – 2:20 pm (Remote)
Location:	via Zoom (https://tamu.zoom.us/j/97001106551)

Lab Instructor Details

Instructor:	Abir Chaudhuri
Office:	CSA 301-B
E-Mail:	abiromu@tamu.edu
Office Hours:	T 4:10 pm – 5:10 pm
Location:	CSA 301-B

Course Description

The coupled human-environment system is comprised of many feedback mechanisms that are often nonlinear and exhibit time-delayed relationships. The social, economic, technological, and environmental changes often pose enormous challenges that affect the quality of our environment, and ultimately human well-being. Addressing these challenges requires perspectives and tools capable of dealing with the ***dynamic complexity*** of these integrated human and biophysical systems. In this course, students will develop systems thinking and system dynamics perspectives and skills. ***Systems thinking*** is a discipline that focuses on recognizing the interrelationships among the components of an entity (e.g., an ecosystem, a city) with the aim of reaching a synthesized view of that entity (the system). ***System dynamics***, as a simulation methodology that is firmly rooted in the systems thinking discipline, allows for quantitative analysis of complex systems.

The course consists of two main parts: In the first part, students will learn about systems thinking philosophy and practice, fundamental systems concepts, and will get familiar with soft systems methodology. In the second part of this course, students will build, modify, and use simple, pedagogical examples of dynamic models of selected socio-economic and biophysical systems drawn from a large spectrum of the global environmental change literature. Examples of these include fishery management, environmental health, urbanization, dynamics of climate change, climate policy, and development of new energy technologies. A systems modeling software will be used to identify key processes and relationships in systems and represent them in models.

Students will also learn how to represent decision-heuristics of ***boundedly rational*** human agents in models and the importance of making the distinction between actual and perceived states of key variables in determining the dynamics of systems. Students will learn to test the models and underlying assumptions and approximations that must be made in modeling, use them to explore system behavior, and assess the validity of the models. Many of these examples will also present opportunities to experiment with formulation of policy options to effectively deal with the problems addressed.

This is primarily a lecture course. Class participation in the lecture sessions is strongly encouraged and will influence your grade positively. You should be aware that ***you will be responsible for all the material contained in the assigned readings as well as what is covered in the lecture***. Furthermore, these two sources of information are not identical. Material which you read but is not discussed in class will appear on examinations (and vice versa). Do not assume that material in the text which is not discussed in class is unimportant. In fact, I will assign you material to read because I do not have time to cover the topic in class. Note that the images/slides used during class sessions are available via Canvas, but they do not include my comments or remarks about them. Therefore, I encourage you to use them for review, but you should not assume that you can substitute viewing the slides for attending class.

Course Prerequisites

Introductory knowledge of algebra and statistics are required. Knowledge of calculus would be useful but **not required**.

Course Learning Outcomes

If students attend lectures, complete reading and other class assignments, they will be able to achieve the following learning objectives in this course:

1) Learn about the history and theory of systems science;
2) Develop an understanding of the fundamental properties of integrated socio-economic and biophysical systems;
3) Critically think about socio-ecological problems from a systems perspective;
4) Gain qualitative and quantitative systems-thinking skills to put this systems perspective into practice in real-life:

   4a) The qualitative systems thinking skills include appreciating the *concept of system* as an entity that is much more than the sum of its parts, defining *system boundaries* to address the problem at hand, identifying *key variables in a system and the interrelationships* among them, representing these variables and interrelationships in the form of *causal loop diagrams*;

   4b) The quantitative systems modeling skills include building *dynamic systems models*, recognizing the *typical dynamic behavior patterns* and their *underlying structural sources*, testing and experimenting with *model assumptions*, performing *scenario analyses*.

Textbook and/or Resource Materials

Required Textbook:

Ford, A. (2009) *Modeling the Environment*. 2nd Edition. Washington, DC: Island Press. 488 p.

You should expect to read each reading assignment from *Modeling the Environment* thoroughly. While reading you will need to ponder over equations, graphs, and diagrams. Readings will help you with the assignments and with a better understanding of the course material.

Suggested Books:

Meadows, D.H. 2008. Thinking in Systems: A Primer. Chelsea Green: White River Junction, VT. 218 p.
Available as ebook:
http://proxy.library.tamu.edu/login?url=https://ebookcentral.proquest.com/lib/tamucs/detail.action?docID=430143

Software:

In this course, students will use the **Vensim** Personal Learning Edition (**Vensim PLE**), a FREE modeling package offered by Ventana Systems. No previous programming experience is needed to use the software. It comes with online user's guide and help, and also contains a folder of demo models. Students can download Vensim PLE at <http://vensim.com/vensim-personal-learning-edition/>.

Additional Readings:

There will be supplementary readings from various books and research articles for students to better appreciate the theoretical underpinnings of systems analysis and its application in various areas. These readings are also **required for those who registered to the 667/601 section of the class**. Those students may encounter questions in the homework assignments from the contents of these readings.

(B) Barlas Y 1996. Formal aspects of model validity and validation in system dynamics. System Dynamics Review 12: 183-210.

(BD) BenDor TK, SS Metcalf, LE Fontenot, B Sangunett, B Hannon. 2006. Modeling the spread of the Emerald Ash Borer. Ecological Modelling 197: 221-236.

(C) Checkland P. 2011. Systems Thinking and Soft Systems Methodology. The Oxford Handbook of Management Information Systems: Critical Perspectives and New Directions. R. D. Galliers and W. L. Currie, Oxford University Press: 87-112.

(F) Fiddaman T. 2007. Dynamics of climate policy. System Dynamics Review 23: 21-34.

(G) Gerst MD and TE Graedel. 2008. In-Use stocks of metals: status and implications. Environmental Science & Technology 42(19):7038-7045.

(GV) Grimm V. 1999. Ten years of individual-based modelling in ecology: what have we learned and what could we learn in the future? Ecological Modelling 115:129-148.

(Ho) Homer J. 1996. Why we iterate: scientific modeling in theory and practice. System Dynamics Review 12: 1-19. (KW) Kessler MA. And Werner BT 2003. Self-organization of sorted patterned ground. Science 299: 102-104.

(L) Leopold A. 1943. Deer irruptions. Wisconsin Conservation Bulletin 8: 1-11.

(M) Moxnes E. 1998. Not only the tragedy of the commons: misperceptions of bioeconomics. Management Science 44: 1234-1248.

(S) Sterman JD. 2000. Business Dynamics: Systems Thinking and Modeling for a Complex World, Irwin McGraw-Hill.

(S02) Sterman JD. 2002. All models are wrong: reflections on becoming a systems scientist. System Dynamics Review 18: 501-531.

Grading Policy

The grading system follows the Texas A&M University grading system:
A = Excellent, B = Good, C = Satisfactory, D = Passing, F = Failing

Grades will be assigned based on the following cutoffs: A ≥ 90%, B = 80-89%, C = 70-79%, D = 60-69%, F < 60%. An average performance in this class will receive a satisfactory grade (C).

Coursework will comprise the following. The percentages in parentheses indicate **grade distribution of final grade**:

Homework assignments (15%)

Homework assignments will be assigned occasionally; you will have two weeks to complete the assignments. The assignments will be composed of short exercises and/or write-ups from the readings. These assignments will be done **individually**.

Lab assignments (35%)

Lab exercises will be assigned almost every week of the semester. The lab assignments will be sufficiently small assignments for most of the students to complete them during the lab session of the class. The labs are due in a week at the beginning of the lab. The background information necessary to complete the assignments will be provided during the lectures and the labs. These assignments will be done **individually**. Brief reports including concise documentation of the model, model output, and the insights on the model will be turned in.

Attending the lab sessions is **required for those who are registered to the 467-501 section of the class.** Each missed attendance will lead to **a 5% decrease in the grade of the corresponding lab assignment.**

Class participation (10%)

Although this is a lecture-based course, there will be ample opportunity for students to participate in the class discussions.

Quizzes (10%)

To make sure that everyone is keeping up with learning the key concepts, there will be **unannounced** quizzes. These will be short, taking about ten minutes of class time.

Group model project (30%)
The groups (3 or 4 students) will be required to develop a (preferably existing) system dynamics model of an environmental issue. The project will allow students to apply the skills they gained during the class to problems of their own interest. The groups will be expected to submit a final report consisting of the developed model and the outputs. The final report should also explain the system components and the interactions and feedbacks amongst them, model building steps, model assumptions, and model calibration and validation procedures. Finally, each group will be required to give an oral presentation at the end of the semester. Details of the report format and presentation requirements will be provided later in semester. The final document for the project is due **December 5, 2024**. For each day that a project is handed in late, there will be an **incremental forfeiture** of the project grade. Projects will not be accepted after December 8.

APA Format and Writing Requirements: All written assignments (including activity assignments and proposal draft, and project assignments) should follow American Psychological Association (APA) format. Use the APA guidelines in the APA Manual (7th edition) or those found at https://apastyle.apa.org/blog/basics-7e-tutorial) to guide the writing and citation process.

All written assignments must be single-spaced in Times New Roman 12 pt., with 1-inch margins all around. Do not add cover pages to the assignments. The specific requirements and formatting guidelines for each assignment will be provided during the semester.

Late Work Policy

- *No late submission of assignments will be accepted. Students who do not submit an assignment by its due date will receive a grade of zero from that assignment.*
- *Work submitted by a student as makeup work for an excused absence is not considered late work and is exempted from the late work policy (See Student Rule 7).*

Course Schedule

This schedule is tentative and subject to change at the discretion of the instructor.

TENTATIVE COURSE SCHEDULE

Wk	Period	Topic	Readings
1	Aug 20	Introduction to systems and systems science	Ch 1
		LAB: Meeting with the TA in the lab & Intro to systems thinking	
	Aug 22	Introduction to systems and systems science (cnt'd)	
2	Aug 27	Systems Thinking	Meadows: Introduction
		LAB: Getting started with Vensim	Ch 2, App A-B
	Aug 29	Soft Systems Methodology	(C)
3	Sep 3	Causal loop diagrams, balancing and reinforcing feedbacks	Ch 9
		LAB: Building a simulation model	UsersGuide: Ch6
	Sep 5	Stocks and Flows	Ch 3
4	Sep 10	Fuzzy Cognitive Mapping	–
		LAB: REVIEW	
	Sep 12	System behavior over time	Meadows: Ch 1
5	Sep 17	Homeostasis; Accumulating the flows; Dynamic equilibrium	Ch 10
		LAB: REVIEW	
	Sep 19	S-shaped growth	Ch 7
6	Sep 24	Material flows and delays	Ch 4, (G)
		LAB: Water flow in the Mono Basin	Ch 5
	Sep 26	Water flows in a basin: Intro to Mono Lake Case	Ch 4-5
7	Oct 1	Modeling Process	Ch 13, (Ho)
		LAB: REVIEW	
	Oct 3	Model validation	Ch 17, (B)
8	Oct 8	**NO CLASS, NO LAB ON Oct 8, TUESDAY *(Fall Break)***	
	Oct 10	REVIEW	
9	Oct 15	Fisheries: Tucannon Salmon Case and Misperceptions of complex dynamics	Ch 15, (M)
		LAB: Tucannon Salmon Case Study	
	Oct 17	Introduction to Oscillations	Ch 18

10	Oct 22	Predator-Prey Dynamics and Intro to Kaibab Deer Herd Case	Ch 20, (L)
		LAB: Kaibab deer herd model, predator-prey dynamics on the Kaibab Plateau	
	Oct 24	Kaibab Deer Herd Case (cont'd)	Ch 20, (L)
11	Oct 29	Managing a Feebate Program for Cleaner Vehicles	Ch 16
		LAB: Feebate simulator game	
	Oct 31	Order and complexity: path dependence	Ch 10 from (S)
12	Nov 5	Climate control on Daisyworld	Ch 11
		LAB: Daisyworld	
	Nov 7	REVIEW	
13	Nov 12	Policy Aspects of Climate and En-ROADS Climate Model	(F)
		LAB: COP29: Baku, Azerbaijan 2024 UN Climate Change Conference	
	Nov 14	Policy Aspects of Climate and En-ROADS Climate Model (cont'd)	
14	Nov 19	Spatio-temporal dynamics: Landscape models	App G, (BD),
		LAB: Lorenz Chaos model & Agent-based modeling	
	Nov 21	Self organization, Agent-based models	(GV)
15	Nov 26	Reflections and Concluding Perspectives	Ch 24, (S02)
		LAB: **NO LAB**	
		NO CLASS on Nov 28, THURSDAY – THANKSGIVING	

University Policies

Attendance Policy

The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments.

Please refer to Student Rule 7 in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy

Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor.

Please refer to Student Rule 7 in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" (Student Rule 7, Section 7.4.1).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" (Student Rule 7, Section 7.4.2).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (See Student Rule 24)

Academic Integrity Statement and Policy

"An Aggie does not lie, cheat or steal, or tolerate those who do."

"Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case" (Section 20.1.2.3, Student Rule 20).

You can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and your rights and responsibilities at aggiehonor.tamu.edu.

Americans with Disabilities Act (ADA) Policy

Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact Disability Resources in the Student Services Building or at (979) 845-1637 or visit disability.tamu.edu. Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible. Disability Resources is located in the Student Services Building or at (979) 845-1637 or visit disability.tamu.edu.

Title IX and Statement on Limits to Confidentiality

Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit gender-based discrimination and sexual harassment, including sexual assault, sexual exploitation, domestic violence, dating violence, and stalking.

With the exception of some medical and mental health providers, all university employees (including full and part-time faculty, staff, paid graduate assistants, student workers, etc.) are Mandatory Reporters and must report to the Title IX Office if the employee experiences, observes, or becomes aware of an incident that meets the following conditions (see University Rule 08.01.01.M1):

- The incident is reasonably believed to be discrimination or harassment.
- The incident is alleged to have been committed by or against a person who, at the time of the incident, was (1) a student enrolled at the University or (2) an employee of the University.

Mandatory Reporters must file a report regardless of how the information comes to their attention – including but not limited to face-to-face conversations, a written class assignment or paper, class discussion, email, text, or social media post. Although Mandatory Reporters must file a report, in most instances, you will be able to control how the report is handled, including whether or not to pursue a formal investigation. The University's goal is to make sure you are aware of the range of options available to you and to ensure access to the resources you need.

Students wishing to discuss concerns in a confidential setting are encouraged to make an appointment with Counseling and Psychological Services (CAPS).

Students can learn more about filing a report, accessing supportive resources, and navigating the Title IX investigation and resolution process on the University's Title IX webpage.

Statement on Mental Health and Wellness

Texas A&M University recognizes that mental health and wellness are critical factors that influence a student's academic success and overall wellbeing. Students are encouraged to engage in proper self-care by utilizing the resources and services available from Counseling & Psychological Services (CAPS). Students who need someone to talk to can call the TAMU Helpline (979-845-2700) from 4:00 p.m. to 8:00 a.m. weekdays and 24 hours on weekends. 24-hour emergency help is also available through the National Suicide Prevention Hotline (800-273-8255) or at suicidepreventionlifeline.org.

"To help protect Aggieland and stop the spread of COVID-19, Texas A&M University urges students to be vaccinated and to wear masks in classrooms and all other academic facilities on campus, including labs. Doing so exemplifies the Aggie Core Values of respect, leadership, integrity, and selfless service by putting community concerns above individual preferences. COVID-19 vaccines and masking — regardless of vaccination status — have been shown to be safe and effective at reducing spread to others, infection, hospitalization, and death."