Boston University College and Graduate School of Arts & Sciences
Undergraduate Academic Program Office
725 Commonwealth Avenue, Room 102

CAS/GRS New Course Proposal Form
This form is to be used when proposing a new CAS or GRS course.

This form should be submitted to Senior Academic Administrator Peter Law (617-353-7243) as a PDF file to pgl@bu.edu. For further information or assistance, contact Associate Dean Joseph Bizup (617-353-2409; jbizup@bu.edu) about CAS courses or Associate Dean Jeffrey Hughes (617-353-2690; hughes@bu.edu) about GRS courses.

DEPARTMENT OR PROGRAM: Earth & Environment DATE SUBMITTED: 10/28/16

COURSE NUMBER: CAS GE 380 S /CAS BI 380 S

COURSE TITLE: SYSTEMS MODELING OF COUPLED HUMAN AND NATURAL SYSTEMS

INSTRUCTOR(S): Sucharita Gopal

TO BE FIRST OFFERED: Sem./Year: Summer___ /__ 2017____

SHORT TITLE: The “short title” appears in the course inventory, on the Link University Class Schedule, and on student transcripts and must be 15 characters maximum including spaces. It should be as clear as possible.

| S | Y | S | T | E | M | S | M | O | D | E | L | I | N | G |

COURSE DESCRIPTION: This is the description that appears in the CAS and/or GRS Bulletin and The Link. It is the first guide that students have as to what the course is about. The description can contain no more than 40 words.

This course presents key elements of systems theory and explores the role of Coupled Human Natural Systems science in advancing issues related to sustainability, climate change, biodiversity conservation, and human and ecosystem well-being. Lab exercises include dynamical systems modeling applications.

PREREQUISITES: Indicate “None” or list all elements of the prerequisites, clearly indicating “AND” or “OR” where appropriate. Here are three examples: “Junior standing or CAS ZN300 or consent of instructor”; “CAS ZN108 and CAS ZN203 and CAS PQ206; or consent of instructor”; “For SED students only.”

1. State the prerequisites:

GE 270 or MA 213 or consent of the instructor; and BI 107

2. Explain the need for these prerequisites:

Systems modeling requires an understanding of system dynamics comprised of equations representing the interactions and flows as well as simulation to understand dynamic behavior, evaluation of alternative policies or choices, and implementation. The process of model creation and simulation stages of systems dynamics is rigorous and therefore requires some quantitative background. We also added consent of the
instructor since we plan to attract some participants who may be very long out of college—i.e., managers and international colleagues.

CREDITS: (check one)

- Half course: 2 credits
- Variable: Please describe.
- x Full course: 4 credits
- Other: Please describe.

Provide a rationale for this number of credits, bearing in mind that for a CAS or GRS course to carry 4 credits, 1) it must normally be scheduled to meet at least 150 minutes/week, AND 2) combined instruction and assignments, as detailed in the attached course syllabus, must anticipate at least 12 total hours/week of student effort to achieve course objectives.

Our course covers a range of topics including extensive labs. Hence we assigned 4 credits.

The course will include 180 min of class meeting per week. In addition to class meeting time, students will be expected to spend at least 8-10 hours per week to complete homework assignments, Labs, and prepare to lead class discussions, and write research projects.

DIVISIONAL STUDIES CREDIT: Is this course intended to fulfill Divisional Studies requirements?

- x No.
- Yes. If yes, please indicate which division ________________ and explain why the course should qualify for Divisional Studies credit. Refer to criteria listed here and specify whether this course is intended for “short” or “expanded” divisional list.

HOW FREQUENTLY WILL THE COURSE BE OFFERED?

- Every semester
- x Once a year, SUMMER
- Once a year, spring
- Every other year
- Other: Explain:

NEED FOR THE COURSE: Explain the need for the course and its intended impact. How will it strengthen your overall curriculum? Will it be required or fulfill a requirement for degrees/majors/minors offered by your department/program or for degrees in other departments/school/colleges? Which students are most likely to be served by this course? How will it contribute to program learning outcomes for those students? If you see the course as being of “possible” or “likely” interest to students in another departments/program, please consult directly with colleagues in that unit. (You must attach appropriate cognate comments using cognate comment form if this course is intended to serve students in specific other programs. See FURTHER INFORMATION below about cognate comment.)

The proposed course provides much needed pedagogical support for BU’s program on coupled human and natural systems (CHANS). This is a research program based at the Pardee Center that brings together faculty and students in Biology, Earth and Environment, the Pardee School for Global Studies, the medical campus, and Questrom. The goal of the program is to grow scientists and practitioners equipped to shape policy about sustainable and just development, while pushing back the existential shadows of climate change, overpopulation, mass extinction and gross inequity. It is somewhat astounding that BU, which aspires to be a world-leading R1 university, offers so little by way of instruction in this area. So far the CHANS program has
been active in engaging undergraduate and graduate students from all of the mentioned programs as well as Kilachand Honors College seniors (for their Keystone projects). Students have been attracted to the integrative theoretical, computational and remote sensing approaches that we have been creating and employing, but there has been no formal means of satisfying their demand to acquire this knowledge and skill set. This is why we decided to create this course. In addition to filling this specific vacuum, the proposed course brings important scientific principles and technical skills to existing programs of study in systems ecology (e.g. biogeosciences), environmental and public health policy, environmental economics, political science and international relations.

ENROLLMENT: How many undergraduate and/or graduate students do you expect to enroll in the initial offering of this course?

15 students in the summer of 2017 including people from other schools interested in systems modeling. In the following years, we expect enrollment to be well over 15.

CROSS-LISTING: Is this course to be cross-listed or taught with another course? If so, specify. Chairs/directors of all cross-listing units must co-sign this proposal on the signature line below.

OVERLAP:

1. Are there courses in the UIS Course Inventory (CC00) with the same number and/or title as this course?
   - [X] No.
   - [ ] Yes. If yes, any active course(s) with the same number or title as the proposed course will be phased out upon approval of this proposal.
   
   NOTE: A course number cannot be reused if a different course by that number has been offered in the past five years.

2. Relationship to other courses in your program or others: Is there any significant overlap between this course and others offered by your department/program or by others? (You must attach appropriate cognate comments using cognate comment form if this course might be perceived as overlapping with courses in another department/program. See FURTHER INFORMATION below.)

FACILITIES AND EQUIPMENT: What, if any, are the new or special facilities or equipment needs of the course (e.g., laboratory, library, instructional technology, consumables)? Are currently available facilities, equipment, and other resources adequate for the proposed course? (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)

Course will be taught in proprietary lab space CAS 435. We will require a license for Simile.

STAFFING: How will the staffing of this course, in terms of faculty and, where relevant, teaching fellows, affect staffing support for other courses? For example, are there other courses that will not be taught as often as now? Is the staffing of this course the result of recent or expected expansion of faculty? (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)
The course will be offered as a summer course and will not impact staffing. If there is continued demand, the course can be converted to a regular course offering. The course will require a research assistant to help run the labs. We are hoping to get an enrollment of over 12 students.

Guest lectures from individuals who have been part of the Coupled Human and Natural Systems network at BU and have worked on marine management, ecosystem valuation and environmental impact studies in many countries including the US, Cambodia, Belize, Brazil and other locations. The team has conducted workshops at various countries including four in Cambodia. This summer course will increase BU’s visibility in this area of modeling and synthesis, and train the next generation of students in ecosystem modeling that is currently being adopted by various non-profits, international agencies and governments. Attract foreign government and non-profit employees to take the course.

BUDGET AND COST: What, if any, are the other new budgetary needs or implications related to the start-up or continued offering of this course? If start-up or continuation of the course will entail costs not already discussed, identify them and how you expect to cover them. (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)

Summer Term salary payments from Summer Term budget.

EXTERNAL PROGRAMS: If this course is being offered at an external program/campus, please provide a brief description of that program and attach a CV for the proposed instructor.

FURTHER INFORMATION THAT MUST BE ATTACHED IN ORDER FOR THIS PROPOSAL TO BE CONSIDERED:

- A complete week-by-week SYLLABUS with student learning objectives, readings, and assignments that reflects the specifications of the course described in this proposal; that is, appropriate level, credits, etc. (See guidelines on "Writing a Syllabus" on the Center for Teaching & Learning website.) Be sure that syllabus includes your expectations for academic honesty, with URL for pertinent undergraduate or GRS academic conduct code(s).

- Cognate comment from chairs or directors of relevant departments and/or programs. Use the form here under "Curriculum Review & Modification." You can consult with Joseph Bizup (CAS) or Jeffrey Hughes (GRS) to determine which departments or programs inside and outside of CAS would be appropriate.

DEPARTMENT CONTACT NAME AND POSITION: Dave Marchant, Chair

DEPARTMENT CONTACT EMAIL AND PHONE: MARCHANT@BU.EDU 3-3236

DEPARTMENT APPROVAL: ___________________________ 11/18/16

Date

Other Department Chair(s) (for cross-listed courses)
CAS/GRS CURRICULUM COMMITTEE APPROVAL:

☐ Approved  Date: ________________
☐ Tabled    Date: ________________
☐ Not Approved  Date: ________________

Divisional Studies Credit:

☐ Endorsed
  ☐ HU
  ☐ MCS
  ☐ NS
  ☐ SS

☐ Not endorsed

______________________________________________________________
Curriculum Committee Chair Signature and Date

Comments:

PROVISIONAL APPROVAL REQUESTED for Semester/Year ________________

______________________________________________________________
Dean of Arts & Sciences Signature and Date

Comments:

CAS FACULTY:  Faculty Meeting Date: ________________  ☐ Approved  ☐ Not Approved

______________________________________________________________
Curriculum Administrator Signature and Date

Comments:
Course Details: CAS GE 380S Summer 2017

Classroom and Schedule: CAS 435

Course Description—Coupled human and natural systems (CHANS) is an emerging field of interdisciplinary science that is used to address natural resource management and sustainability questions at an ecosystem scale. Rooted in systems theory, CHANS science seeks to understand the connections, feedbacks, and trajectories that occur as a result of natural system and human system processes and exchange. An important goal of CHANS science is to uncover the current and future limits of natural system function to support human wellbeing needs (food, freshwater, economic opportunities) and explore the benefits and losses (i.e. tradeoffs) associated with alternative futures. **In this course, we present key elements of systems theory and explore the role of CHANS science in advancing issues related to sustainability, climate change, biodiversity conservation, human and ecosystem wellbeing, environmental justice, and more.** Dynamical systems models are an important tool to advance CHANS science. These models account for coupled systems features and interactions, simulate CHANS processes, and allow us to examine how natural and human system features unfold over time and space.

One CHANS modeling approach is called Multiscale Integrated Model of Ecosystem Service (MIMES) and was developed by course instructor Boumans. The MIMES approach has been applied widely to address a variety of sustainability questions including how to develop marine spatial plans in the Gulf of Maine, how to buffer the against impacts from dams and water development in the Mekong Basin in Southeast Asia, and the sustainable design of aquaculture in Lake Victoria, Africa. MIMES models depicting these and other case studies will be the emphasis of modeling labs where students will learn to design, construct, analyze, and interpret CHANS behavior and explore systems level outcomes under various decision making scenarios.

Course Objectives—through this course, students will gain the following knowledge and skills:
- A basic understanding of General Systems Theory
- The ability to systematize interactions that generate Earth’s processes including within the anthroposphere, the biosphere, atmosphere, lithosphere, and hydrosphere.
- Explain the basic concepts of systems thinking, models, and their application to ecosystem service valuation
- Develop detailed conceptual models of complex systems
- Translate conceptual models into dynamic quantitative models and run simulations
- Evaluate and explain CHANS dynamics to a variety of multiple stakeholders

Course Instructor
Dr. Suchi Gopal, Professor, Geography and Environmental Studies
675 Commonwealth Av #459
Phone: 617-353-5744
Email: suchi@bu.edu

Guest Lecturers:
Dr. Irit Altman, Assistant Research Professor, Biology Department
Dr. Roel Boumans, President Affordable Futures, Pardee Center Fellow
Dr. Les Kaufman, Professor, Biology Department
**Course Website:** For an updated and complete version of the course syllabus, lecture notes, labs and project descriptions, visit http://learn.bu.edu. Stay tuned since all announcements will be made here regularly.

**Course Texts:**
- Additional Selected readings identified in the class schedule below

**Course Schedule:** The class is organized into three sections of learning and study outlined below. A full description of the content and goals for each section is outlined in Appendix A.

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**Section 1: CHANS Introduction, background, theory and practice (Weeks 1 and 2)**

**Week 1**

Lecture 1: CHANS Introduction, Background, Theory and Practice  
Lecture 2: Coupled flows: Ecosystem service and human impact dynamics  
Lab 1: Getting started with Simile modeling  
Readings:
- *Thinking in Systems: A Primer*  
  - Introduction: The Systems Lens  
  - Chapter 1: The Basics  
  - Chapter 2: A Brief Visit to the Systems Zoo  
  - Mind mapping exercise – Understanding agricultural system of Tulalips

**Week 2**

Lecture 3: Applying CHANS and Intro to MIMES  
Lecture 4: Towards an emergent theory of CHANS  
**Written Assignment Due: 1-page on applying CHANS framework to real world issues**  
Lab 2: Model Scoping, Design, and Parametrization  
Readings
- *Thinking in Systems: A Primer*  
  - Chapter 3: Why Systems Work So Well  
  - Chapter 4: Why Systems Surprise Us  
  - Chapter 5: Systems Traps…and Opportunities

**Section 2: Approaches to systems modeling of CHANS (Weeks 3 and 4)**

**Week 3**

Lecture 5: CHANS Models; Digging deeper into MIMES approach  
Lecture 6: Introduction to Case Studies  
***MIDTERM IN-CLASS EXAM***  
Lab 3: Model Verification, Validation, and Calibration  
Readings:

**Week 4**

Lecture 7: Case Studies Cont.: Understanding and believing emergent behavior  
Lecture 8: Forecasting the future  
**Mini-Project Proposal Due**  
Lab 4: Interpreting baseline results  
Readings:
Thinking in Systems: A Primer

- Chapter 6: Leverage Points—Places to Intervene in the System
- Chapter 7: Living in a World of Systems

Section 3: Problem solving using a CHANS approach (Weeks 5 and 6)

Week 5
Lecture 9: Scenario development and envisioning alternatives
Lecture 10: Understanding and communicating tradeoffs
Lab 5: Scenario Development and Analysis
Readings:

Week 6
Lecture 11: Uncertainty
Lecture 12: Student presentations of mini-projects

*Mini-Project Report Due*

Lab 6: Tradeoff Analysis and Communication
Readings
  - Selected Readings TBD

Mini-Project Description—Students will work in small groups to design and develop a CHANS model using a systems approach. Students will work on a case study of their choice and can either select a model that has previously created by the instructor team (these include Cambodia, Lake Victoria, Mass Bay, and other systems), or develop a new model. The goals of mini-projects are to verify that the model structure and components are well designed, calibrate the model and run relevant scenarios. Students will then present results of this work in a way that communicates the findings to relevant decision makers associated with the CHANS system. A collaboratively written report and group presentation is required during the final week of the class.

Course Grading

<table>
<thead>
<tr>
<th>Activity</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>In class participation</td>
<td>5%</td>
</tr>
<tr>
<td>Midterm Exam</td>
<td>25%</td>
</tr>
<tr>
<td>Lab Assignments</td>
<td>30%</td>
</tr>
<tr>
<td>Other written assignments</td>
<td>10%</td>
</tr>
<tr>
<td>Mini-project</td>
<td>30%</td>
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</tbody>
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Late Policy: Late assignments will be accepted with a 10% penalty per day late. Once the exercise has been graded and returned to the class it will no longer be accepted. Exceptions can be made for students who proactively reach out if they are unwell.
Academic Conduct Code: Students are required to understand and adhere to the Boston University Academic Conduct Code. The Code can be found at [http://www.bu.edu/academics/policies/academic-conduct-code/](http://www.bu.edu/academics/policies/academic-conduct-code/)

Suspected violations of the code will be discussed with the student AND reported to the Dean, and dealt with in accordance with university policy.

Disability Accommodations:
Accommodations for students with disabilities will be provided in accordance with the policies of Boston University.

APPENDIX A

Section 1: CHANS Introduction, background, theory, and practice (Weeks 1 and 2)
What are ‘coupled human and natural systems’, how do we study them, and how can CHANS science be used to solve real world problems? In the first section of the class we introduce the concept of CHANS and discuss its emergence as an interdisciplinary field of study. Using concepts from systems thinking as a guide, we will consider fundamental characteristics of CHANS systems including their ‘emergent behavior’, embedded negative and positive feedbacks, and lagged responses. We will explore ways of observing and uncovering the mechanisms underlying CHANS behavior. After building a sound understanding of what CHANS are and how we may study them, the class will explore a range of real world problems that can be informed using this interdisciplinary systems approach.

Section 2: Approaches to CHANS systems modeling (Weeks 3 and 4)
In this section we focus on systems modeling and other analytical approaches to understand CHANS. While the emphasis will be on modeling, we will begin with some more simple quantitative approaches to understanding complex systems states and behavior (e.g. parametric and non-parametric multivariate techniques for visualization and analysis as well as time series approaches). We will orient students to the role of different classes of systems models, discussing the differences between scoping, research, and scenario models and the context in which these are best suited for use. Students will learn aspects of systems model design and use knowledge of hierarchical processes to conceptualize model structure. In this section we will also focus on the opportunities and limits of data for CHANS and discuss the use of local ecological and social knowledge. Currently, a variety of systems modeling approaches are used to understand CHANS including GIS based methods and various open source platforms. We will discuss the range of modelling approaches available for CHANS study, with an emphasis on the MIMES approach.

Section 3: Problem solving using a CHANS approach (Weeks 5 and 6)
The focus of this section is how CHANS science can help inform current environmental and sustainability challenges and support decision making. The emphasis will be on developing scenarios, analyzing, visualization, and communication. This portion of the class will emphasize case studies analysis. We will explore not only the types of CHANS understanding and modeling output necessary to address real world problems, but also the importance of appropriate and targeted visualization and communication strategy necessary to influence people’s thinking and decisions.
Appendix – Other Reading, Web and Videos

Leverage Points: Places to Intervene in a System - by Donella Meadows. This article illustrates how a systems approach can be used to create societal change.


Linking Thinking - New Perspectives on Thinking and Learning for Sustainability – http://www.eauc.org.uk/wwf_linking_thinking_new_perspectives_on_thinking_ (link broken) - This handbook from the World Wildlife Federation was written as an introduction to systems thinking to help educators and students develop their own latent abilities to think relationally.

Videos

https://www.ted.com/talks/tom_wujec_got_a_wicked_problem_first_tell_me_how_you_make_toast?language=en
http://www.ted.com/talks/eric_berlow_how_complexity_leads_to_simplicity
https://www.youtube.com/watch?v=dUqRTWCDxt4

The Man Who Stopped the Desert provides a good example of how complex systems operate.
https://www.youtube.com/watch?v=kK3of0cVA3U