Master of Science in Sustainable Management

Climate Risk & Scenario Analysis [SUMAK6132]
[Tuesdays – 6:00pm – 8:00 pm]
3 credits
Elective

Instructors: Satyajit Bose sgb2@columbia.edu
Dong Guo guodong@columbia.edu

Office Hours: By Appointment via Zoom: [TBD]
Response Policy: I usually respond within 24 hours to email inquiries.

Facilitator/Teaching Assistant: [Desikan Jayaram (dj2658@columbia.edu) and Himanshhu Panwar (hp2637@columbia.edu)]

Course Overview

The course provides an overview of the scenario analysis and climate risk modeling process for corporate issuers and government entities. There is a brief introduction to the climate models utilized by the IPCC, both global and regional. There is a description of the scenario generation and analysis process, with linkages to benchmark scenarios outlined by international bodies. This is followed by a review of the linkages between climate models and socio-economic variables in the form of integrated assessment models, Ricardian models and economic input-output analysis. There is one module on the information systems needed to ensure good adaptation and a review of best practices and guidelines for climate risk management strategies. Integrated examples of climate risk and opportunities for specific issuers are discussed in the last 2 classes. The problem sets and exercises are designed to provide practice in applying high-level guidelines and climate damage relationships to the strategies and operations of specific countries, industries and companies.

The course has the following related goals:

1. To provide students with an introduction to the quantitative analysis of climate-related damages, cost differentials across mitigation approaches and the relative risk reduction value of adaptation investments.
2. To equip students with econometrically-equipped and geospatially aware approaches to analyze and interpret climate-related scenario analysis and integrate this knowledge into strategic planning and risk mitigation for corporations and governments.
3. To prepare students to understand and apply proposed SEC guidelines for the identification and quantification of climate risks, fostering alignment with industry practices and anticipating policy responses.

Who should take this course?

- Sustainability practitioners seeking to enhance their skills in scenario analysis and climate risk assessment to drive positive environmental and business outcomes.
- Business professionals aiming to gain insights into climate risk management strategy and integrate environmental considerations into their decision-making processes.
- Finance professionals interested in understanding the implications of climate change for investment strategies and financial planning.

Learning Objectives

By the end of the course, students should to be able to:

L1 Describe methods of estimating climate damages: Outline the methodologies and frameworks used for estimating climate-related damages to businesses and economies, and their significance in risk assessment.

L2 Identify business risks and opportunities: Learn how to systematically identify, quantify, and assess the specific risks and opportunities that climate change poses to different sectors and industries, incorporating these insights into corporate strategy.

L3 Integrate scenario analysis: Practice the implementation of risk management scenarios aligned with international standards and adapted to local conditions, so as to render such scenarios relevant to both strategic and operational decision making.

L4 Apply regulatory guidelines: Assess the implications of proposed regulatory guidelines for the identification and quantification of climate risks, review organizational practices aligned with these guidelines, and prepare for potentially broader policy responses and supply chain impacts.

L5 Quantify value of adaptation investments: Develop the ability to quantitatively assess the value of investments in adaptation strategies or climate-related opportunities, considering their potential returns and contributions to resilience in the face of climate related impacts.

Required Readings


13. J.P.Morgan. (2022, November). Climate scenarios: What they are, why they are important, and how they are applied to.


Assignments and Assessments
Your final course grade will be computed using a weighted index of numeric grades that combine performance under written assignments (discussion boards and weekly assignments), attendance and participation, the midterm exam, and the final term project. The weighted index will be scaled into a letter grade scale from F to A+ based on an expectation that a class representative of the population of Columbia masters students will receive a median grade of B+ or A-.

Specific rubrics for each assignment will be provided on the Canvas course site. General evaluation criteria is provided in each description.

Participation (Individual) - 10% of final grade

Regular participation in class discussions and project activities is required. Students are expected to have done the readings for each session prior to the lecture. We expect your contributions to enhance the quality of the class experience for yourself and others.

Participation includes the pre-reading required for the class and participation in the online discussion boards. Both written and oral participation is expected.

Problem Sets (Individual) - 15% of final grade

Completion of three weekly problem sets that include solving simple quantitative problems with climate damage functions, risk decision analysis and computation of optimal adaptation strategies.

Scenario Analysis Tools (Groups of 3-4 people) - 15% of final grade

Regional climate simulation exercise using DICE/EnROADS tool

A climate scenario analysis exercise utilizing an Excel-based simulation tool will form the basis for a group exercise to evaluate the impact of assumed decarbonization pathways on regional macro-economic variables such as economic growth, employment rates and temperature changes. Groups will be provided with a specific region and a benchmarked scenario to simulate, with an emphasis on described the assumed relationships which drive the results.

Green infrastructure adaptation investment assessment using CLASIC Tool

In this assignment, students are expected to conduct a financial analysis of the cost of undertaking green infrastructure adaptation in an urban area to minimize the impacts of excessive rainfall caused by climate change on the city’s infrastructure and to articulate the financial benefits of the investment. Each group will receive a specific land use area whose geospatial characteristics can be analyzed in the open source online tool CLASIC. The tool, combined with desk research for cost estimates, can be used to estimate the probability and economic damage from urban flooding estimates.

Midterm Exam (Individual) - 30% of final grade

At the end of week 9, students are given 48 hours to complete a written take-home midterm exam. This exam will require students to evaluate the potential climate damages and opportunities, using quantitative analysis, for one out of 2-3 given organizations. Students will conduct desk research on the nature of the business, connect strategy and operations with benchmark scenarios and identify material climate risks and opportunities. Students will utilize climate damage relationships covered in the class readings to articulate a strategy for quantitatively assessing identified risks for the chosen organization. The report must include how strategy and operations are likely to be affected and how management may identify synergistic business opportunities. The analysis must include estimated impacts to revenues, operating income, asset and liability values. Students will be required to submit a Word document and supporting spreadsheets with their response of approximately 2,000 words, excluding references.

**Final Term Project (Groups of 2-3 people) - 30% of final grade**

The final project will require students to work in teams to prepare either a draft TCFD-style report with enhanced quantitative analysis for a corporate issuer, or a climate risks & opportunities strategy report for a government agency. Deliverables will consist of presentation recording, slide deck, Excel analysis and written report. Students will select the issuer or government entity. The written report is expected to be a draft climate risk report section suitable for publication under the proposed SEC climate disclosure guidelines.

**Grading**

The final grade will be calculated as described below:

### FINAL GRADING SCALE

<table>
<thead>
<tr>
<th>Grade</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>A+</td>
<td>98–100 %</td>
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<tr>
<td>A</td>
<td>93–97.9 %</td>
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<tr>
<td>A-</td>
<td>90–92.9 %</td>
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<tr>
<td>B+</td>
<td>87–89.9 %</td>
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<tr>
<td>B</td>
<td>83–86.9 %</td>
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<tr>
<td>B-</td>
<td>80–82.9 %</td>
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<tr>
<td>C+</td>
<td>77–79.9 %</td>
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<td>C</td>
<td>73–76.9 %</td>
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<td>C-</td>
<td>70–72.9 %</td>
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<td>D</td>
<td>60–69.9 %</td>
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<tr>
<td>F</td>
<td>59.9% and below</td>
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<thead>
<tr>
<th>Assignment/Assessment</th>
<th>% Weight</th>
<th>Individual or Group/Team Grade</th>
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<tbody>
<tr>
<td>Class participation</td>
<td>10%</td>
<td>Individual</td>
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<tr>
<td>Problem sets</td>
<td>15%</td>
<td>Individual</td>
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Group climate tool-based exercises (simulation and adaptation) | 15% | Group
Midterm: climate risk & opportunity report | 30% | Individual
Final project | 30% | Group

Course Schedule/Course Calendar
SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards. You are required to read these standards within the first few days of class. Ignorance of the School’s policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

Accessibility Columbia is committed to providing equal access to qualified students with documented disabilities. A student’s disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University’s Health Services website: http://health.columbia.edu/services/ods/support

<table>
<thead>
<tr>
<th>Module/Week &amp; Topic with specific dates</th>
<th>Topic Covered</th>
<th>Readings</th>
<th>Activities/Assignments for this module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 1 Introduction</td>
<td>Understanding climate change and its impact on businesses.</td>
<td>(IPCC, 2021) (pp. 18-24) (6 pages)</td>
<td>Introduction to Student Backgrounds</td>
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<td></td>
<td>Importance of climate risk and scenario analysis</td>
<td>(TCFD, 2017) (pp. 1-30) (30 pages)</td>
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<td>SEC Climate risk disclosure</td>
<td>(Tol, 2018) (21 pages)</td>
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<tr>
<td>Module 2 Climate Modeling - I</td>
<td>Brief introduction to Global Climate Models (GCMs)</td>
<td>(IPCC, 2021) (pp. 6-17) (11 pages)</td>
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<td></td>
<td>Interannual Variation &amp; Climate Variability</td>
<td>(David Bader, 2008), Chapter 2. (18 pages)</td>
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<td>(Khan, Mohaddes 2021) (13 pages)</td>
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<td>Astrum. “What El Nino Will do to Earth in 2022.” YouTube Video (15 minutes)</td>
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<td>Module 3 Climate Modeling - II</td>
<td>Regional Climate Models, Downscaling, Meso-scale, synaptic scale</td>
<td>(HW Tenfie, 2022) (18 pages)</td>
<td>Problem Set</td>
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<td>(Kamal Ahmed, 2019) (21 pages)</td>
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<td>Module 4 Scenario Analysis- I</td>
<td>Input variables, relationships, estimated uncertainty, output variables</td>
<td>(J.P. Morgan, 2022) (8 pages)</td>
<td>Problem Set</td>
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<td></td>
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<td>(TCFD, 2017) (pp. 12-28) (16 pages)</td>
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<tr>
<td>Module 5 Scenario Analysis - II</td>
<td>Benchmark scenarios: UNFCCC (RCP and SSP), IEA, NGFS</td>
<td>(IPCC, 2021) (pp. 29-39) (10 pages)</td>
<td>Problem Set</td>
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<td>(NGFS, 2020) (pp. 9-34) (25 pages)</td>
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| Module 6 | Integrated Assessment Models-I | Introduction to IAMs  
Different models used for scenario analysis and their pros/cons  
Social cost of carbon | (Raymond R. Tan, 2019) (pp. 1-28) (28 pages)  
(Gillingham & Stock 2018) (20 pages) |
|---|---|---|---|
| Module 7 | Integrated Assessment Models-II | Details on EnRoads Simulator and  
Dynamic Integrated Climate-Economy (DICE) Model | (Nordhaus W. D., Scientific and Economic Background on DICE models, 2020)  
(Nordhaus W., 2013) (11 pages).  
(Nordhaus W. D., Revisiting the social cost of carbon, 2017) (pp. 1518-1523) (5 pages)  
Simulation Exercise: Analyzing Climate-Economy Interactions with the DICE Excel Model |
| Module 8 | Ricardian Models of Climate Impact | Panel-based econometric methods  
Impact of weather realizations over time in a given geography  
Linkages and extrapolation to impacts on economic growth | Auffhammer (2018) (21 pages)  
(Dell, Jones & Olken 2014) (58 pages)  
(Burke, Hsiang & Miguel 2015) (16 pages)  
| Module 9 | Sectoral Models of Climate Impact-I | Input Output Model Fundamentals for sustainable industrial system  
Case studies  
Matrix Algebra and Environmentally extended IOMs | (Raymond R. Tan, 2019) (14 pages)  
(Yi Yang, 2017) (10 pages)  
Midterm |
| Module 10 | Sectoral Models of Climate Impact-II | Application of IOM models to assess GHG impact in Industries for different sectors | (Yi Yang Y. P.-S., 2022) (7 pages)  
(Kompas, Pham & Che 2018) (21 pages) |
| Module 11 | Information and Adaptation | Early warning signals interpretation from regional models  
Financing the adaptation techniques  
Possibility of Maladaptation | (Aerts, 2018) (pp. 1-33) (33 pages)  
(ERAMS Classic, 2021) | Green infrastructure economic analysis exercise using CLASIC tool |

Module 12  
**Risk management strategies**
- TCFD/TNFD, targets, governance
- Climate VAR
- Example Metric: FRBNY Global Supply Chain Pressure Index

Module 13  
**Vulnerability Identification**
- Climate Change vulnerability and its impact on global economy
- Identification of vulnerability and factors affecting it
- Case Study: Thailand Flooding 2011

Module 14  
**Opportunity Identification**
- Opportunity Identification Framework
- Application for different sectors
- Case Study: Electric Utility, PG&E and Tuscan Electric Power

Course Policies

*Participation and Attendance*
I expect you to come to class on time and thoroughly prepared. I will keep track of attendance and look forward to an interesting, lively and confidential discussion. If you miss an experience in class, you miss an important learning moment and the class misses your contribution. More than one absence will affect your grade.

*Late work*
Work that is not submitted on the due date noted in the course syllabus without advance notice and permission from the instructor will be graded down 1/3 of a grade for every day it is late (e.g., from a B+ to a B).

*Citation & Submission*
All written assignments must use standard citation format (e.g., MLA, APA, Chicago), cite sources, and be submitted to the course website (not via email).

School and University Policies and Resources

*Copyright Policy*
Please note—Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

**Academic Integrity**
Columbia University expects its students to act with honesty and propriety at all times and to 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. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times.

SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at [https://sps.columbia.edu/students/student-support/academic-integrity-community-standards](https://sps.columbia.edu/students/student-support/academic-integrity-community-standards). You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

**Diversity Statement**
It is our intent that students from all diverse backgrounds and perspectives be well-served by this course, that students’ learning needs be addressed both in and out of class, and that the diversity that the students bring to this class be viewed as a resource, strength and benefit. It is our intent to present materials and activities that are respectful of diversity: gender identity, sexuality, disability, age, socioeconomic status, ethnicity, race, nationality, religion, and culture.

**Accessibility**
Columbia is committed to providing equal access to qualified students with documented disabilities. A student’s disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: [https://health.columbia.edu/content/disability-services](https://health.columbia.edu/content/disability-services).

**Class Recordings**
All or portions of the class may be recorded at the discretion of the Instructor to support your learning. At any point, the Instructor has the right to discontinue the recording if it is deemed to be obstructive to the learning process.

If the recording is posted, it is confidential and it is prohibited to share the recording outside of the class.

**SPS Academic Resources**
The Division of Student Affairs provides students with academic counseling and support services such as online tutoring and career coaching: https://sps.columbia.edu/students/student-support/student-support-resources.

Columbia University Information Technology
Columbia University Information Technology (CUIT) provides Columbia University students, faculty and staff with central computing and communications services. Students, faculty and staff may access University-provided and discounted software downloads.

Columbia University Library
Columbia's extensive library system ranks in the top five academic libraries in the nation, with many of its services and resources available online.

The Writing Center
The Writing Center provides writing support to undergraduate and graduate students through one-on-one consultations and workshops. They provide support at every stage of your writing, from brainstorming to final drafts. If you would like writing support, please visit the following site to learn about services offered and steps for scheduling an appointment. This resource is open to Columbia graduate students at no additional charge. Visit http://www.college.columbia.edu/core/uwp/writing-center.

Career Design Lab
The Career Design Lab supports current students and alumni with individualized career coaching including career assessment, resume & cover letter writing, agile internship job search strategy, personal branding, interview skills, career transitions, salary negotiations, and much more. Wherever you are in your career journey, the Career Design Lab team is here to support you. Link to https://careerdesignlab.sps.columbia.edu/

Netiquette
Online sessions in this course will be offered through Zoom, accessible through Canvas. A reliable Internet connection and functioning webcam and microphone are required. It is your responsibility to resolve any known technical issues prior to class. Your webcam should remain turned on for the duration of each class, and you should expect to be present the entire time. Avoid distractions and maintain professional etiquette.

Please note: Instructors may use Canvas or Zoom analytics in evaluating your online participation.

More guidance can be found at: https://jolt.merlot.org/vol6no1/mintuwimsatt_0310.htm Netiquette is a way of defining professionalism for collaborations and communication that take place in online environments. Here are some Student Guidelines for this class:

- Avoid using offensive language or language that is not appropriate for a professional setting.
- Do not criticize or mock someone’s abilities or skills.
- Communicate in a way that is clear, accurate and easy for others to understand.
- Balance collegiality with academic honesty.
- Keep an open-mind and be willing to express your opinion.
- Reflect on your statements and how they might impact others.
- Do not hesitate to ask for feedback.
- When in doubt, always check with your instructor for clarification.