

Course Syllabus: Climate Change - PSE 205

Offering Department	Physical Science and Engineering
Course Number	PSE 205
Course Title	Climate Change
Academic Semester	Fall 2024/2025
Semester Start Date	08/25/2024
Semester End Date	12/11/2024
Class Schedule (Days & Time)	Climate Change Lecture PSE 205 Mon, Thu 10:00 - 11:30, Building 9 - Classroom 3131 (41)

Instructor(s)				
Name	Email	Phone	Office Location	Office Hours
Frans Stephan Peter van Buchem	FRANS.VANBUCHEM@KAUST.EDU.SA			
Ana Margarida Lobo Lourenco Costa	anamargarida.costa@kaust.edu.sa		4508, 16, Administration (bldg. 16)	
Hylke Edward Beck	HYLKE.BECK@KAUST.EDU.SA		3204, 1, Al-Khawarizmi (bldg. 1)	

Teaching Assistant(s)

Course Information	
Course Description	<p>The aim of this course is to raise the awareness about the fundamentals of climate change, how it is impacting our societies and what solutions are proposed in the corporate and governmental institutions. It will prepare students for a more meaningful participation and contribution to the societal debates on these topics, and improve their evaluation capacity of information from media, scientific reports and papers. The course is structured in four modules: The first one introduces the scientific fundamentals of climate change studies starting with a view in the deep past how climate has always changed, and which factors were driving this, to the more recent past with the influence on human evolution, societies and cultural development. The present-day climate system will be introduced, with its main drivers, and the challenges of modeling it. The second one deals with the impact of climate change on our present-day world, the observed degradation of terrestrial and marine ecosystems, the challenges of the urban environment, and the unknown tipping points and feedback systems driving climate change. In the third and fourth modules society's response to climate change will be addressed, both from the point of view of policies such as the drive for sustainability and zero carbon (energy transition), as well as the response of the corporate</p>

	and governmental world to these challenges and the financial consequences and opportunities.
Learning Outcomes	This course aims to prepare students for a meaningful participation and contribution to the societal debates on climate change, by improving their evaluation capacity of information from media, scientific reports and papers, and identifying opportunities in the wider corporate world to contribute to impactful solutions.
Textbook/Materials	References to key publications will be provided during the course
Method of Assessments	10.00% - Homework /Assignments 20.00% - Oral presentation 30.00% - Group Project(s) 20.00% - Final exam 20.00% - Attendance and Participation
Nature of the Assignments	After every cluster of lectures there is an evaluation session which will be filled in by: Module 1: Presentations by students summarizing a particular topic presented in the lectures and completed with additional information from a suggested reading list; Module 2: Climate and remote sensing data analysis using basic software that provides insights in the functioning and the state of the climate system; Module 3: A moderated discussion session, with a panel including students; Module 4: 'The World's Future' is a simulation game designed to unite participants in a virtual environment, fostering a collective understanding of the global challenges outlined by the 17 Sustainable Development Goals. In this simulated reality, students assume specific roles representing various sectors, such as government, IGOs, and society. They will have the opportunity to prioritize issues, plan and implement solutions, and resolve conflicts through negotiation and dialogue. The reporting on this role play will be by video-clip; Final Exam: For the final exam the students will have to write an essay on a topic from a provided list.
Course Policies	Timely attendance and active participation is expected. Homework assignments need to be handed in in time.
Additional Information	The course has three principal instructors: Prof. Frans van Buchem, Prof. Hylke Beck and Prof. Ana Costa. Methods of assignment will be completed once the system is upgraded.

Tentative Course Schedule (Time, topic/emphasis & resources)		
Week	Lectures	Topic
1	Mon 08/26/2024 Thu 08/29/2024	1. Introduction (F. van Buchem, H. Beck, A. Costa) 2. Earth is a unique planet (F. van Buchem) – time and space, the universe, orbital control
2	Mon 09/02/2024 Thu 09/05/2024	3. Climate change in the geological past (F. van Buchem) – geological processes, reading the rocks 4. The Quaternary climate and human evolution (F. van Buchem)
3	Mon 09/09/2024 Thu 09/12/2024	5. The climate system – components, drivers and features (H. Beck) 6. Climate monitoring – variables, techniques, error margins (H. Beck)
4	Mon 09/16/2024 Thu 09/19/2024	7. Climate modeling – global observation systems, data assimilation (H. Beck) 8. Evaluation - Student presentation assignment
5	Thu 09/26/2024	9. Climate change since the industrial revolution (T. Patzek)
6	Mon 09/30/2024 Thu 10/03/2024	10. Terrestrial biodiversity and ecosystems and degradation (F. Maestre) 11. Marine biodiversity and ecosystems and degradation (R. Peixoto)
7	Mon 10/07/2024 Thu 10/10/2024	12. Aerosol and climate (S. Osipof) 13. Impacts of climate change on urban environments (A. Costa)
8	Mon 10/14/2024 Thu 10/17/2024	Mid Semester Break on 14 October 14. Climate change mitigation (B. Dally)

Week	Lectures	Topic
9	Mon 10/21/2024 Thu 10/24/2024	15. Evaluation - climate and remote sensing data analysis exercise 16. Climate prediction: limitations and uncertainties (H. Beck)
10	Mon 10/28/2024 Thu 10/31/2024	17. GHG accounting and management (A. Costa/S. Al Ghamdi) 18. Climate related policies, agreements & organizations (Princess Mashael/A. Costa)
11	Mon 11/04/2024 Thu 11/07/2024	19. Sustainable development and climate change (A. Costa) 20. Food and water supply (P. Hong)
12	Mon 11/11/2024 Thu 11/14/2024	21. Evaluation- moderated discussion session with students in the panel (Costa/van Buchem/Beck) No lecture on 14 Nov.
13	Mon 11/18/2024 Thu 11/21/2024	22. Corporate: Aramco; tbd (contact F. van Buchem) 23. IGO: Islamic Development Bank, Jeddah; tbd (contact A. Costa)
14	Mon 11/25/2024 Thu 11/28/2024	24. Corporate: Google; chief sustainability officer, Kate Brandt (contact A. Costa) 25. IGO: Green Climate Fund; Executive Director, Mafalda Duarte (contact A. Costa)
15	Mon 12/02/2024 Thu 12/05/2024	26. The World's Future - A Game About the SDGs (A. Costa) 27. The World's Future - A Game About the SDGs – evaluation with video report (A. Costa)
16	Mon 12/09/2024	Exam week

Note

The instructor reserves the right to make changes to this syllabus as necessary.

Course Syllabus: Decision Making in Sustainability - AMCS 204

Offering Department	Dept of Appl Math&Computational Sc
Course Number	AMCS 204
Course Title	Decision Making in Sustainability
Academic Semester	Spring 2024/2025
Semester Start Date	01/26/2025
Semester End Date	05/21/2025
Class Schedule (Days & Time)	Decision Making in Sustainability Lecture AMCS 204 Mon,Thu 16:00 - 17:30, Building 9 - Classroom 3128 (55)

Instructor(s)				
Name	Email	Phone	Office Location	Office Hours
Maria Alexandra Gomes	Alexandra.Gomes@KAUST.EDU.SA		4303, 1, Al-Khawarizmi (bldg. 1)	Every time I am in my office or email for appointment.

Teaching Assistant(s)

Course Information	
Course Description	Decision Making in Sustainability is a graduate course designed to equip students with the quantitative and analytical skills needed for effective decisions in the framework of sustainability challenges. This course uses real-world case studies to demonstrate how mathematics can be combined with the foundational principles of sustainable development to enable informed decision-making for environmental, social, and economic prosperity. The students will engage with mathematics from a practical standpoint, with emphasis on applied techniques and user-oriented perspective, rather than technical theory.
Learning Outcomes	By the end of this course, the students will be able to 1. use the appropriate mathematical tools to make informed and efficient decisions in sustainable development, considering the relevant environmental, social, and economic aspects; 2. understand the assumptions, limitations and potential of different approaches in decision making; 3. use mathematics to evaluate current sustainability practices and policies, identify areas of improvement and propose evidence-based solutions to meet the United Nations Sustainable Development Goals; 4. communicate their findings to technical and non-technical audiences, providing full justification of the methods used, their assumptions and limitations, and corresponding implications on the findings.
	1) Marion Hersh. Mathematical Modelling for Sustainable Development. Environmental

Textbook/Materials	<p>Engineering Series, 1st edition, Springer, Germany, 2006.</p> <p>2) Hamdy A. Taha. Operations Research: An Introduction. 10th edition, Pearson Education Limited, England, 2017.</p> <p>3) Dimitris Bertsimas and Robert M. Freund. Data, Models, and Decisions: The Fundamentals of Management Science. South-Western College Publishing, Thomson Learning, USA, 2000.</p> <p>4) Michael Resnik. Choices: An Introduction to Decision Theory. 1st edition, University of Minnesota Press, USA, 1987.</p>
Method of Assessments	<p>60.00% - Course Project(s)</p> <p>40.00% - Group Project(s)</p>
Nature of the Assignments	<p>Throughout the semester, students will create their own code step by step, integrating modules covered in each topic as homework assignments. Every student selects their own programming language or software, depending on their background. Group projects are not mandatory but are encouraged. By the end of the course, each student will have a comprehensive code capable of analyzing a case study. The final course grade will be based on the functionality of the code (60% evenly distributed among the homework assignments) and the student decision making analysis of a case study (40%).</p>
Course Policies	<p>Attendance is mandatory for all classes unless prior approval for absence is obtained from the instructor and/or the student's PI. Collaboration among students is encouraged as part of the learning process; however, each student must individually write their own code and complete their own work. The instructor may request evidence of individual contributions, such as answering questions related to the submitted work. Late homework submissions will not be accepted under any circumstances, and students are expected to manage their time and responsibilities accordingly.</p>
Additional Information	<p>The prerequisites for this course are undergraduate-level knowledge of calculus, probability, statistics, and basic programming skills. However, students who do not fully meet these prerequisites but are motivated to learn are encouraged to register. The course is designed to provide support and resources to help all students succeed, regardless of their starting point.</p>

Tentative Course Schedule (Time, topic/emphasis & resources)		
Week	Lectures	Topic
1	Mon 01/27/2025 Thu 01/30/2025	Sustainable development: concept, principles, and historical context.
2	Mon 02/03/2025 Thu 02/06/2025	Linear Optimization.
3	Mon 02/10/2025 Thu 02/13/2025	Linear Optimization.
4	Mon 02/17/2025 Thu 02/20/2025	Linear Optimization. Case Study 1.
5	Mon 02/24/2025 Thu 02/27/2025	Integer Linear Optimization.
6	Mon 03/03/2025 Thu 03/06/2025	Integer Linear Optimization. Extension of Case Study 1.
7	Mon 03/10/2025 Thu 03/13/2025	Multiobjective Optimization.
8	Mon 03/17/2025 Thu 03/20/2025	Multiobjective Optimization. Case Study 2.
9	Mon 03/24/2025 Thu 03/27/2025	Analytic Hierarchy Process. Extension of Case Study 2.
10	No schedule	Decision Making Under Risk: Expected Value Criterion and Posterior Probabilities. Case Study 3.

Week	Lectures	Topic
11	Mon 04/07/2025 Thu 04/10/2025	Decision Making Under Risk: Utility Functions. Extension of Case Study 3.
12	Mon 04/14/2025 Thu 04/17/2025	Decision Making Under Uncertainty: Laplace criterion (principle of insufficient reason), minmax/maxmin, Savage regret criterion. Case Study 4.
13	Mon 04/21/2025 Thu 04/24/2025	Game Theory.
14	Mon 04/28/2025 Thu 05/01/2025	Game Theory. Case Study 5.
15	Mon 05/05/2025 Thu 05/08/2025	Final Projects.
16	Mon 05/12/2025 Thu 05/15/2025	Final Projects.

Note

The instructor reserves the right to make changes to this syllabus as necessary.

Course Syllabus: Principles of Env.Sustainability - EnSE 205

Offering Department	Dept of Environmental Sc. & Eng.
Course Number	EnSE 205
Course Title	Principles of Env.Sustainability
Academic Semester	Spring 2024/2025
Semester Start Date	01/26/2025
Semester End Date	05/21/2025
Class Schedule (Days & Time)	Principles of Env.Sustainability Lecture EnSE 205 Mon,Thu 08:30 - 10:00, Building 9 - Classroom 4225 (50)

Instructor(s)				
Name	Email	Phone	Office Location	Office Hours
Matthew Francis McCabe	Matthew.McCabe@kaust.edu.sa			
Sami Ghurmullah Al-Ghamdi	SAMI.ALGHAMDI@KAUST.EDU.SA		2226, 4, Al-Jazri (bldg. 4)	

Teaching Assistant(s)	
Name	Email
Dr. Furqan Tahir	For Prof Sami G. Al-Ghamdi (furqan.tahir@kaust.edu.sa)
Dr. Anissa Nurdiawati	For Prof Sami G. Al-Ghamdi (anissa.nurdiawati@kaust.edu.sa)

Course Information	
	<p>The course provides a general introduction to some fundamentals of sustainability, examining aspects of what constitutes the rates of renewable resource harvest, pollution creation, and non-renewable resource depletion, where these processes can be continued indefinitely, i.e., without sacrificing the needs of future generations. The course explores a range of topics, including water and energy cycles, resource accounting and climate change. Studies on the water-food energy nexus, the carbon cycle, emissions and sequestration, concepts of green design and life-cycle analysis will also be reviewed. The course is designed to equip students with a more focused understanding of some of the key issues related to sustainability and earth system stewardship. While general in nature, it will provide students with the knowledge required to make informed decisions and evaluate economically feasible actions that are in the interests of protecting the natural world.</p>

Course Description

The course is divided into two related sections, with material presented by Kim Choon Ng (Part 1) and Prof Sami G AL-Ghamdi (Part 2)

Part 1: The course is general in nature, covering the general understanding of what constitutes to the rates of renewable resource harvest, pollution creation, and non-renewable resource depletion where these processes can be continued indefinitely, i.e., without sacrificing the needs of future generations. It is a course to better equipped students for making informed decisions and taking economically feasible actions now that are in the interests of protecting the natural world.

Lecture slides cover the chronological activities of human activities by examining the quantifiable parameters such as the green-house gases, climate change, loss of agricultural land to erosion, etc. We want to generate awareness to the possible irreversible situations of the fragile world environment, with emphasis on preserving the capability of the environment to recover itself and not causing too much climate changes.

Environment sustainability is an important topic at the present time, as seen by the current COP21 that is taking place in Paris in early December, 2015. Based on scientific evidence, we realize that damages to our world can be catastrophic if no appropriate actions are adopted now. For example, many human activities conducted hitherto can potentially be causing

- (i) damage rainforests and woodlands through logging and agricultural clearing,
- (ii) seawater pollution (acidification) and over-fishing of oceans, rivers and lakes,
- (iii) polluting the atmosphere through the burning of fossil fuels,
- (iv) damaging prime agricultural and cultivated land through the use of unsustainable farming practices, etc.

With clear environmental policy and targets (e.g., the $< 2\text{°C}$ limit for average rise in the ambient temperature), there is a good chance that policy incorporated by countries to individual corporation can ensure indefinite growth in the businesses or economic growth without jeopardizing our environment and all countries can have GDP growth levels that are sustainable.

Students are required to conduct one assignment where they can exercise independent studies, either alone or in group of two or three students.

In the problem-based learning, they will analyze and propose solution(s), as well as articulate methodologies in solving problems of interest to our human activities that currently deemed "unsustainable". They are encouraged to conduct economic analysis, either simple life cycle analysis (LCA), or any suitable economic analysis, etc. (by Prof. Sami G. Al-Ghamdi)

Part 2 (Prof. Sami G. Al-Ghamdi):

The need for sustainable engineering is fueling the development of novel tools and techniques for studying the behavior of industrial systems and their relationship with the biosphere and society. Life Cycle Assessment (LCA) is an environmental modeling method that has become increasingly popular within business and academia for evaluating the environmental impacts of products or systems. LCA considers impacts along the entire life cycle, from production to consumption to disposal, and generally provides quantitative information for a range of different environmental issues to inform decisions.

This course enables students to develop a practical understanding of the intellectual foundation and standards of LCA, common databases and software packages used, and their application to products and systems. Process-based analysis models, input-output and hybrid approaches are presented for life cycle assessment. This is a research-based course and is suitable for students interested in researching in depth a particular topic.

This course will introduce graduate students to this important and rapidly growing field. It will introduce the emerging principles of LCA, provide insight into the nature of interaction between industrial, ecological systems. By the end of the course, students will have an awareness of analytical tools/resources for evaluating sustainability employing a systems perspective. Knowledge of the LCA is essential for environmentally sound engineering decision-making. The students will demonstrate the ability to perform applicable material and/or energy balances related to LCA. The students will learn how to model sustainability engineering from a systems/process perspective with associated inputs and outputs.

The objectives of this introductory course are to provide awareness to students on the "stresses" created by human activities, often driven by relentless economic development with no regards to the environment. We will also gain an understanding of earth system dynamics

Learning Outcomes	<p>and the key processes that sustain our existence. Student are encouraged to explore ways to protect our environment through the assignment problems.</p> <p>Secondly, it imparts deeper understanding of environmental sustainability - a wiser use of resources in the context of economic, social and environment nexus. Basic engineering science knowledge, concern for environment, and open mind to project-based learning.</p> <p>Reference text: As per prescription during the lectures</p>
Textbook/Materials	<p>There are no specific textbooks required for this course. Students are encouraged to rely on and thoroughly study the lecture slides and materials provided by the professors. Additional readings and resources, including articles, case studies, and reports, will be recommended during the lectures to complement the topics discussed.</p>
Method of Assessments	<p>20.00% - Homework /Assignments 40.00% - Research Project 30.00% - Group Project(s) 10.00% - Attendance and Participation</p>
Nature of the Assignments	<p>Assignments in this course are designed to foster independent learning, critical thinking, and collaborative problem-solving. Students will engage in tasks that emphasize real-world applications of sustainability principles, focusing on addressing challenges deemed "unsustainable" in current human activities. Assignments encourage students to analyze problems, propose solutions, and articulate methodologies for addressing key environmental and societal issues.</p> <p>Students will have the opportunity to conduct assignments independently or in small groups of two or three. Assignments will include problem-based learning activities, requiring students to apply economic analyses, such as simple life cycle assessments (LCA) or other suitable methodologies, to evaluate sustainability impacts and propose actionable strategies.</p> <p>Part I (by Matthew McCabe): Assignments in this section emphasize understanding the Earth system, its processes, and humanity's role in influencing these dynamics. Assessment is structured as follows: (5%) Class Attendance and Participation: Active participation in discussions is required to engage with course material critically. (10%) Assignment: A focused task to analyze and apply concepts covered in class. (15%) Class Debate (Team Mark): Collaborative debates on sustainability topics, allowing students to defend evidence-based perspectives. (20%) Individual Project Report: A detailed report on a debate-related topic, demonstrating analytical and critical thinking skills.</p> <p>Part II (by Sami G. Al-Ghamdi): This section emphasizes applying sustainability tools and methodologies, particularly LCA and Environmental Product Declarations (EPD). Assessment includes: (5%) Class Attendance and Participation: Students are expected to contribute actively to discussions. (10%) Assignment: Lifecycle Thinking: An analysis of sustainability principles in the context of human activities and resource management. (15%) Assignment: Environmental Product Declaration: A task focused on developing EPDs and understanding their role in sustainability. (20%) Final Project - LCIA: A comprehensive project using Life Cycle Impact Assessment (LCIA) to evaluate and model the environmental impacts of products, systems, or processes.</p> <p>These assignments are structured to build both foundational knowledge and practical skills, preparing students to address sustainability challenges with informed and innovative solutions.</p>
Course Policies	<p>Assignment Submission: All assignments, including written reports, must be submitted on time. Failure to submit a written report will result in a zero mark unless a valid and compelling reason is provided in advance.</p> <p>Class Attendance and Participation: Active participation in class discussions is a key requirement for this course. Attendance will be monitored, and consistent engagement is expected.</p> <p>Academic Integrity: Students are expected to maintain the highest standards of academic honesty. Plagiarism, cheating, or any other form of academic misconduct will not be tolerated and may result in</p>

	<p>disciplinary action.</p> <p>Extensions and Late Submissions: Extensions may be granted for valid reasons if requested prior to the assignment deadline. Late submissions without prior approval will be penalized.</p> <p>Changes to Policies or Assignments: The instructor reserves the right to make necessary changes to the syllabus, assignments, or policies. Any updates will be communicated promptly to students.</p>
Additional Information	<p>Communication: Regularly check the course platform for updates and resources.</p> <p>Office Hours: Professors will provide office hours for questions and guidance; details will be shared in the first week.</p> <p>Support: Utilize university resources, such as the library and writing center, to enhance your learning.</p>

Tentative Course Schedule (Time, topic/emphasis & resources)		
Week	Lectures	Topic
1	Mon 01/27/2025 Thu 01/30/2025	Introduction; Global water cycles; Regional issues and challenges
2	Mon 02/03/2025 Thu 02/06/2025	Water Resources and budgets; Virtual Water, Water Security
3	Mon 02/10/2025 Thu 02/13/2025	Sustainable Systems – Nature Based Solutions
4	Mon 02/17/2025 Thu 02/20/2025	Climate Changes – Past to Present
5	Mon 02/24/2025 Thu 02/27/2025	Climate Change – Present to Future
6	Mon 03/03/2025 Thu 03/06/2025	Climate Implications; the Water-Food-Energy Nexus
7	Mon 03/10/2025 Thu 03/13/2025	Project Team Debates (Part 1)
8	Mon 03/17/2025 Thu 03/20/2025	Project Team Debates (Part 2)
9	Mon 03/24/2025 Thu 03/27/2025	Introduction to Sustainability and Environmental Impact Assessment
10	No schedule	Mid-semester Break - Eid Al-Fitr Break
11	Mon 04/07/2025 Thu 04/10/2025	Quantifying Environmental Impacts
12	Mon 04/14/2025 Thu 04/17/2025	Assessment Methodologies and Comparative Analysis

Week	Lectures	Topic
13	Mon 04/21/2025 Thu 04/24/2025	Life Cycle Assessment & Practical LCA Applications
14	Mon 04/28/2025 Thu 05/01/2025	Regulations, Standards, and Best Practices
15	Mon 05/05/2025 Thu 05/08/2025	Advanced Tools, Emerging Trends, and Mitigation Strategies
16	Mon 05/12/2025 Thu 05/15/2025	Final Projects and Course Wrap-Up

Note

The instructor reserves the right to make changes to this syllabus as necessary.