INTEG 441: Hard Decisions and Wicked Problems

(held with ERS 675, GEOG 694)

Overview: Every day, nuanced decisions are made at a personal level (what job offer to accept), an organizational level (whether to recall a faulty product), and in the form of public policy (when and where to develop renewable energy). This course introduces decision analytic tools for systematically structuring messy problems to identify trade-offs among different decisions and to explore them intelligibly. For public policy problems, the challenges of values conflicts and "truth decay" (i.e., the political polarization or outright rejection of facts) will be considered. Additional decision contexts that push the limits of traditional analytic approaches will also be addressed (e.g. wicked problems, deep uncertainty).

Meeting time: MW 4:00 PM – 5:20 PM
Meeting place: According to schedule, EV2-2069 or computer labs (Geddes, EV2-1002A; Galileo, EV1-240)
Instructor: Dr. Vanessa Schweizer, vanessa.schweizer@uwaterloo.ca
Office hours: In EV1-211. Ideal time (MWF) will be selected with class and posted to LEARN.

Objectives: By the end of this course, you should be able to

1) Articulate differences between 'normal' uncertainty (borrowing from Kuhn's concept of normal scientific inquiry) *vs.* deep uncertainty
2) Explain the complementary relationship that scientific investigation can play to decision making (especially for public policy) and its importance (i.e. policy-relevant science, science-policy interface, science-society interface)
3) Apply a variety of decision-analytic techniques for the purposes of problem definition and policy analysis
4) Construct and analyze simple models for decision problems, where you are able to
   a) Recommend at least one intervention that would be worthwhile to pursue (or avoid) and explain why;
   b) Perform an appropriate sensitivity analysis of your results;
   c) Discuss the limitations of your simple model and important considerations (e.g. caveats, sensitive issues, unresolved issues) for a decision or for future research.
5) Apply skills in written communication for technical and general audiences (i.e., journalistic writing)

Required texts:

- *Making Hard Decisions with DecisionTools,* 3rd edn, by Robert T. Clemen and Terence Reilly, 2014
- *Thinking, Fast and Slow* by Daniel Kahneman, 2013

Required software (available at Geddes/Galileo computer labs.):

- Palisade DecisionTools Suite (comes with text; includes PrecisionTree and @RISK).
- ScenarioWizard (freely available at https://www.cross-impact.de/english/CIB_e_ScW.htm)

Additional reading selections may be from the following books and articles:

- *The Honest Broker* by R. Pielke Jr.
- EPRI scenarios report
- *Truth Decay* by J. Kavanagh & M.D. Rich
- M. Haasnoot on adaptive policy pathways
- *Decision Making under Deep Uncertainty* edited by Marchau et al.
- M. Gong et al. on scenarios vs. forecasts

Course evaluation (*grad students):

Obj.	Deliverable	% Final Grade
1-4	**Participation**	**60% / *65%**
	• Correct completion of 6 problem sets	(30%)
	• Participation in 5 seminars	(25% / *30%)
	• Participation in the Sustainable Delta Game	(5%)
4-5	**Final project**	**40% / *35%**
	• Analytical report	30%
	• Op-ed	(10% / *5%)

Participation: This mark will be affected by how well you prepare for and participate in class.

- ***Problem sets.*** Decision analysis is learned best by doing. Selected solutions to problem sets will be presented in class in small groups, where group membership will be *randomized*. To be prepared for these activities, you must complete assigned problem sets.
- ***Seminars.*** *Graduate students* will lead one seminar of their choice (10% of final grade; other seminars, where graduate student participating, worth 5% each); *undergraduate students* are responsible for seminar participation only. Participation will be assessed through written (LEARN Discussion Board) and verbal (in-class) contributions.

Individual *vs.* group work: Students are encouraged to work together on problem sets and to discuss readings and lectures outside of class. Such discussion and group problem solving can improve individual understanding and learning. However, for writing assignments and completion of problem sets, students must produce original work from individual effort, maintaining their academic integrity. Knowing how to balance discussion with others while avoiding copying and other academic offenses can seem tricky. Some suggestions:

- After you discuss a project or idea with a colleague, take a one-hour break to have dinner, watch Netflix, workout – do whatever you like – before writing up the idea. This ensures it comes out in your own words, and it will allow you to confirm that you have integrated it into your own thinking (acquired new knowledge) rather than just reproduced the discussion.
- When working on problem sets, start solo. Attempt the problem on your own before seeing how a fellow student solved the problem. If you are stuck and unsure how to start, be able to explain why you are stuck or confused. This ensures that when you talk with a fellow student, you get help thinking the problem through rather than simply getting 'the answer'.

The **final project** may be done individually or in a small group of no more than three students. There are advantages to doing the project individually as well as in a group. Students doing projects relevant to their theses may prefer to work on their own. Students who wish to engage in peer education (for example, mentoring and improving fellow students' capacities) may work in a small group. *If working as a group,* the project will be considered a single, consistent, coherent submission from all group members and not the monumental efforts of a few participants. Achieving this will involve coordination, cooperation, and checking each other's work – and may involve diplomatically encouraging some group members to step up and others to step back.

Course audit: Students wishing to have the course listed on their transcripts as an audit are expected to attend all classes and must complete all problem sets. Since no mark is recorded for an audit, it is optional for auditing students to make corrections to problem sets, complete writing assignments, or do a final project.

Assignment submission

Problem sets

- Problem sets will be discussed and reviewed in class. Please upload a **completed** copy of your problem set to LEARN prior to the start of class (legible photos are OK). Even if you completed the problem set incorrectly, the floor credit for ***completing*** it *on time* is 62%. Incomplete problem sets are ineligible for correction credit (see below).
- During class, consult with your peers on how you solved the problem. If you made errors, you can upload **corrections** after class to raise your mark for the problem set (to a maximum correction score of 80%).
- Grace days (explained below in the section on late submissions) can be applied toward problem sets, but the maximum benefits of thinking the problem through with peers and the instructor comes with completing the problem set on time.

Writing assignments (i.e., the Final Project) are to be submitted by what would be the start of class on the specified due date electronically to the INTEG 475 LEARN portal. **Be sure to follow directions for assignment submission. If you do not, the mark on your assignment is subject to a 5% penalty** for not following directions. Failing to provide the electronic copy in **PDF format** will result in a penalty. These penalties are in place because reformatting and/or anonymizing your files slows marking down for the entire class, and nobody wants that!

LEARN: Users can login to LEARN via: http://learn.uwaterloo.ca/. Use your WatIAM/Quest username and password. Course documents (syllabus, assignments, copies of slide handouts) will be posted in LEARN. Due to strict copyright restrictions from the publisher, a downloadable file of the slides cannot be provided. Instead a copy of slide handouts will be posted to LEARN.

Late submissions: Each student will be allocated a total of 4 grace days, which allow assignments to be handed in late without penalty. At the end of the term, I will total the number of late days (including weekends), subtract 4, and you will receive a 1% penalty on your **overall course grade** for each late day beyond the grace days. For example, if Essay 1 is late by 3

days, and your second problem set is late by 4 days, you will receive an overall late penalty of 3% at the end of the term. If either format (paper or electronic as appropriate) arrives on time, the assignment is considered on time. ***NOTE: Bear in mind the 5% assignment penalty for submissions that do not follow directions. For writing assignments, it is in your interest to always submit a printed copy on time along with uploading it to LEARN.***

Unclaimed assignments: Unclaimed assignments will be retained until one month after term grades become official in Quest. After that time, they will be destroyed in compliance with UW's confidential shredding procedures.

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University policies and services

Mental Health: The University of Waterloo, the Faculty of Environment and our Departments consider students' well-being to be extremely important. We recognize that throughout the term students may face health challenges – physical and/or emotional. **Please note that help is available.** Mental health is a serious issue for everyone and can affect your ability to do your best work. Counselling Services (**www.uwaterloo.ca/counselling-services**) is an inclusive, non-judgmental, and confidential space for anyone to seek support. They offer confidential counselling for a variety of areas including anxiety, stress management, depression, grief, substance use, sexuality, relationship issues, and much more.

Note for students with disabilities: The AccessAbility Office located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. *If you require academic accommodations to lessen the impact of your disability, please register with the AccessAbility Office at the beginning of each academic term. Accommodations such as extra time on exams, extensions on due dates, etc. must be initiated through the AccessAbility Office.*

Turnitin.com: Text matching software (Turnitin®) may be used to screen assignments in this course. Turnitin® is used to verify that all materials and sources in assignments are documented. Students' submissions are stored on a U.S. server, therefore students must be given an alternative (e.g., scaffolded assignment or annotated bibliography), if they are concerned about their privacy and/or security. Students will be given due notice, in the first week of the term and/or at the time assignment details are provided, about arrangements and alternatives for the use of Turnitin in this course.

It is the responsibility of the student to notify the instructor if they, in the first week of term or at the time assignment details are provided, wish to submit alternate assignment.

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. (**www.uwaterloo.ca/academicintegrity/)**
Students who are unsure what constitutes an academic offence are requested to visit the on-line tutorial at ***http://www.lib.uwaterloo.ca/ait/***

Plagiarism: It is expected that all students will, in all that they do, maintain standards of attribution that recognize the work and contributions of others. In particular, it is expected that you will cite your sources in your written work in a consistent, standard format. There's nothing wrong with building on the work of others, provided you refrain from *plagiarism.* If you are uncertain what constitutes plagiarism, refer to this resource put together for Waterloo graduate students: **https://youtu.be/sWrFrB9EsAo**

Ethical Behaviour: To ensure an environment of tolerance and respect, the University believes that the right of individuals to advance their views openly must be upheld. The realization of these intentions requires respect for general principles of equal recognition for equal work (i.e., a discrimination-free environment); academic freedom for open, respectful, and sensitive debate; and freedom to work in a supportive, respectful, and tolerant environment. As this course interfaces with an external client(s), any violations of ethical behaviour by external parties should be brought to the attention of the instructor, university staff, or a peer. For information on categories of offenses, vehicles for redress, responsibilities of faculty/staff/students who receive complaints or perceive unethical behaviour, and resources for advice and support, students should refer to Policy 33 – Ethical Behaviour, **https://uwaterloo.ca/secretariat/policies-procedures-guidelines/policy-33**

Discipline, or Consequences of Academic Offences:

A student is expected to know what constitutes academic integrity, to avoid committing academic offenses, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offense, or who needs help in learning how to avoid offenses (e.g., plagiarism, cheating, unethical behaviour) or about "rules" for group work/collaboration should seek guidance from the course professor, academic advisor, or the Undergraduate Associate Dean. When misconduct has been found, disciplinary penalties will be imposed under Policy 71 – Student Discipline. For information on categories of offenses and types of penalties, students should refer to Policy 71 - Student Discipline, http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm

Within ENV, those committing academic offences (e.g. cheating, plagiarism, unethical behaviour) will be placed on disciplinary probation and will be subject to penalties that may include a grade of 0 on affected course elements, 0 on the course, suspension, and expulsion.

GRIEVANCE
A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance.
Read Policy 70 - Student Petitions and Grievances, Section 4,
www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please contact your Undergraduate Advisor for details.

APPEALS
A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition; https://uwaterloo.ca/secretariat-general-counsel/policies-procedures-guidelines/policy-70), or Policy 71, Student Discipline (https://uwaterloo.ca/secretariat-general-counsel/policies-procedures-guidelines/policy-71), may be appealed if there is ground. A student who believes they have ground for appeal should refer to Policy 72, Student Appeals (https://uwaterloo.ca/secretariat-general-counsel/policies-procedures-guidelines/policy-72).

Intellectual Property: Students should be aware that this course contains the intellectual property of their instructor, the University of Waterloo, and/or external clients. Intellectual property includes items such as:

- Lecture content, spoken and written (and any audio/video recording thereof);
- Lecture handouts, presentations, and other materials prepared for the course (e.g., PowerPoint slides);
- Questions or solution sets from various types of assessments (e.g., assignments, quizzes, tests, final exams); and
- Work protected by copyright (e.g., any work authored by the instructor or TA or used by the instructor or TA with permission of the copyright owner).

Course materials and the intellectual property contained therein, are used to enhance a student's educational experience. However, sharing this intellectual property without the intellectual property owner's permission is a violation of intellectual property rights. For this reason, it is necessary to ask the instructor, TA and/or the University of Waterloo for permission before uploading and sharing the intellectual property of others online (e.g., to an online repository).

Permission from an instructor or the University is also necessary before sharing the intellectual property of others from completed courses with students taking the same/similar courses in subsequent terms/years. In many cases, instructors might be happy to allow distribution of certain materials. However, doing so without expressed permission is considered a violation of intellectual property rights.

Please alert the instructor if you become aware of intellectual property belonging to others (past or present) circulating, either through the student body or online. The intellectual property rights owner deserves to know (and may have already given their consent).

Research ethics: Please also note that the University of Waterloo requires all research conducted by its students, staff, and faculty that involves humans as participants to undergo prior ethics review and clearance through the Director, Office of Human Research and Animal Care (Office). The ethics review and clearance processes are intended to ensure that projects comply with the Office's Guidelines for Research with Human Participants (Guidelines) as well as those of provincial and federal agencies, and that the safety, rights and welfare of participants are adequately protected. The Guidelines inform researchers about ethical issues and procedures which are of concern when conducting research with humans (e.g. confidentiality, risks and benefits, informed consent process, etc.). If the development of your

research proposal consists of research that involves humans as participants, please contact the course instructor for guidance and see **https://uwaterloo.ca/research/office-research-ethics**

Religious observances: Please inform the instructor at the beginning of term if special accommodation needs to be made for religious observances that are not otherwise accounted for in the scheduling of classes and assignments.

Tentative schedule of classes.

Date	Topic/Activity	Due
WK 1: Sep 4 (W)	Overview of decision analysis and deep uncertainty	—
Sep 9 (M)	Modeling decisions, Ch.2: Elements of decision problems, wicked problems	—
WK 2: Sep 11 (W)	Structuring decisions, Ch. 3: Objectives hierarchies and networks, influence diagrams, decision trees	Problem set 1
Sep 16 (M)	Structuring decisions with software (PrecisionTree) **(Lecture in Galileo lab, EV1-240)**	—
WK 3: Sep 18 (W)	Making choices, Ch. 4: Risk profiles and multiple objectives	Problem set 2
Sep 23 (M)	Decision trees and risk profiles with PrecisionTree **(Lecture in Galileo lab, EV1-240)**	—
WK 4: Sep 25 (W)	Seminar 1 – Climate change: What's all the fuss?	• Climate **change** readings • Problem set 3
Sep 27 (F)	Special Event: Global Climate Strike @Waterloo Square	
Sep 30 (M)	Guest Speaker: Real-World Decision Analysis with Robert Gooding-Townsend	Climate **scenario**/ technical readings
WK 5: Oct 2 (W)	Ch. 5: One-way sensitivity analysis **(Lecture in Galileo lab, EV1-240)**	
Oct 7 (M)	Modeling uncertainty, Ch. 7: Probabilities	
WK 6: Oct 9 (W)	• Discussion of problem set #4 • Final Project launch • Mid-term course evaluation	Problem set 4
Oct 14-18	Thanksgiving and Fall Reading Week (no class meetings)	

Tentative schedule of classes.

Oct 21 (M)	Seminar 2: Thinking, Fast and Slow	• Kahneman • Seminar 2 Readings
WK 7: Oct 23 (W)	Modeling uncertainty, Ch. 9: Using theoretical probability distributions **(Lecture in Galileo lab, EV1-240)**	—
Oct 28 (M)	Modeling uncertainty, Ch. 11: Monte Carlo simulation **(Lecture in Galileo lab, EV1-240)**	—
WK 8: Oct 30 (W)	• Discussion of problem set #5 • Transition to Seminar 3	Problem set 5
Nov 4 (M)	Seminar 3: Decision analysis under certainty, uncertainty, deep uncertainty	Seminar 3 Readings
WK 9: Nov 6 (W)	Guest Speaker: A computational approach to qualitative scenarios (**Lecture in Galileo lab, EV1-240**) (NOTE: VS possibly away)	Weimer-Jehle (2006)
Nov 11 (M)	Modeling preferences, Ch. 14-15: Risk attitudes (utility theory), paradoxes, and implications for decision making	—
WK 10: Nov 13 (W)	Modeling preferences, Ch. 16: Conflicting objectives	—
Nov 18 (M)	Discussion: Problem set #7 and revisiting Slow Thinking	Problem set 7 (MHD)
WK 11: Nov 20 (W)	Seminar 4 – Evidence-based decision-making: What's our verdict?	Seminar 4 Readings
Nov 25 (M)	Simulation games: The Sustainable Delta Game (SD Game) **(Lecture in Galileo lab, EV1-240)**	Problem set 6 (CIB)
Nov 26 (T)	(HW due date → → →)	SD Game 'history' posted to D-board
WK 12: Nov 27 (W)	Seminar 5: Reactive vs. proactive policy under uncertainty (The SD Game and Dynamic Adaptive Policy Pathways)	Seminar 5 Readings
Dec 2 (M)	Writing for decision makers: Reports and op-eds	—
'FINAL'	Final project (including op-ed); due date finalized as a class	