

Course Syllabus

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Science and Policy of Climate Change

ENVI 3010 (4 Credits / 60 class hours)

Local Faculty

International Honors Program:

Climate Change: The Politics of Food, Water, and Energy

Fall 2019

PLEASE NOTE: This syllabus is representative of a typical term. Because courses develop and change over time to take advantage of unique learning opportunities, actual course content varies from semester to semester.

Climate change is both a natural and human-induced phenomenon, which affects the sustainable development of societies in different ways. This course is intended to provide the foundational scientific concepts for students to understand the drivers and impacts of anthropogenic climate change. However, anthropogenic climate change needs to be understood as a multi-faceted environmental *and* political crisis. To the extent that science can help us deal with climate change as a matter of natural resource management, it also has a profoundly political dimension. Despite the consolidation of scientific consensus around climate change, an underlying assumption we take in this course is that the most crucial yet vexing solutions are political. This course therefore also aims to critically engage with the science/policy interface. We examine local, regional, and national mitigation and adaptation strategies as a matter of natural resource management and social policy. We learn about environmental governance mechanisms at local and regional levels, national climate policy frameworks, and global climate change negotiations.

Foundational concepts of climate change science that will be covered include: Earth's climate system and its major components, systems theory, climate system dynamics and spatial patterns, feedback loops, matter/energy flows, and energy/heat transfer processes, climate change history, and climate modelling. Some of the policy topics that may be addressed include: The institutional architecture of climate change policy-making mechanisms at global and national levels, the history and current status of global climate change negotiations, the role of science and technology in mitigation and adaptation strategies, the cost-effectiveness of different climate change mitigation and adaptation strategies in regard to local and national realities, and the role of risk assessments in risk-reduction strategies.

Methodology

This course follows an interdisciplinary perspective that combines different knowledge and fields of expertise from both social and physical sciences. Class discussions will rely on peer-reviewed articles across a wide range of disciplines, as well as on policy documents and NGO reports. The course will closely complement the Comparative Issues in Food, Water, and Energy and the Political Economy and Environmental Change courses, as well as site visits and guest lectures in each country, in order to address the global issue of climate change science and policy from different angles and in different national and local contexts.

Learning Outcomes

Upon completion of the course, students will be able to:

- Explain the basic science of climate change and its impacts on ecosystems and human societies in relation to other drivers of environmental change
- Evaluate potential strategies and response mechanisms aimed at climate change mitigation and adaptation
- Explain the notion of vulnerability and the differentiated capacity of individuals and communities to cope with and adapt to climate change and disaster risks
- Critically assess the role of science and technology in mitigation and adaptation efforts, their potential as well as limitations
- Understand the role of policy in climate change mitigation and adaptation efforts at the national level, and the contentious geopolitics of climate change negotiations at the global level
- Describe the actors and institutions engaged in national and global climate change policy efforts
- Show familiarity with the legal frameworks involved relevant to national climate change policies

Evaluation and Grading Criteria

Assessment:

Class Participation	10%
Policy Briefs on Climate Change Policy Responses	30%
Distance-Learning Quizzes	30%
Final Exam	30%

Self-Assessment: Class participation (10%)

Students are expected to participate actively in sessions and to complete required readings before class in order to understand and engage the material presented. Participation in the class requires not only attendance but also active engagement and curiosity in discussions, activities, guest lectures and field visits, as well as a supportive attitude towards other students.

Policy Briefs on Climate Change Policy Responses (30%)

For this in-class, open-book / open-notes, and timed group assignment, each group will act as an advisor to a government official in Vietnam (first brief), and Morocco (second brief). Each group can select the level of government (national, state/province, municipal), and the type of climate change response strategy (mitigation and/or adaptation). For the policy brief, each group should review relevant data and scientific (including social scientific) knowledge on climate change impacts and policy

options, and recommend one or more specific policy actions to pursue. The brief should be 1000-1200 words excluding references. Please include the url of any online material you reference. Further instructions / grading criteria will be distributed in class.

Quizzes for distance-learning modules (30%)

The distance-learning modules constitute our in-house climate change science textbook tailored to our program and the contexts of each country/region we visit. The modules can be engaged with independently or in small groups that you are free to organize. They provide overall and country-based background on climate change science suitable for all levels. Those with a science background may consider some of this a refresher, while to others this material may be new. You will have four quizzes on this material, in San Francisco (8/26/19), in Vietnam (9/5/19), in Morocco (10/16/19), and Bolivia (date TBD). You are encouraged to email Alan Forsberg with any questions (alan.forsberg@ihp.edu) throughout the semester.

Final Exam: The science and policy of climate change (30%)

Students will be asked to respond to a combination of short answer and essay questions as part of a final summative assessment of their learning on this course. This test will take place towards the end of the Bolivia segment of the program, exact date TBD.

Grading Scale

94-100%	A	Excellent
90-93%	A-	
87-89%	B+	
84-86%	B	Above Average
80-83%	B-	
77-79%	C+	
74-76%	C	Average
70-73%	C-	
67-69%	D+	
64-66%	D	Below Average
Below 64	F	Fail

Expectations and Policies

- Show up prepared. Be on time, have your readings completed and questions in mind for discussion or clarification. Being prepared raises the level of class discussion for everyone. This includes being punctual and prepared for guest lectures and site visits. All students are expected to be present at every program session, with the only exceptions being illness (written note required from a non-IHP adult, e.g. homestay parent, or preferably, health care professional). Unexcused absences and habitual lateness will result in penalties reflected in your participation grade. Please inform the traveling faculty or fellow if tardiness is anticipated.
- Have assignments completed on schedule and done in accordance with the specified requirements. This will help ensure that your assignments are returned in a timely manner. Points will be deducted for assignments turned in late.
- Ask questions in class. Be attentive, respectful and engaged with the guest lecturers and site visit hosts. These are often very busy professionals and community leaders who are doing us an honor by meeting with us and deserve your full attention and respect.

- Comply with academic integrity policies (no plagiarism or cheating, nothing unethical). Any plagiarism or cheating will result in a score of zero for that assignment and could result in additional disciplinary measures as outlined in the Academics section of the IHP Student Handbook.
- Respect differences of opinion (classmates, lecturers, site visit hosts, homestay families). You are not expected to agree with everything you hear, but you are expected to listen across difference and consider other perspectives with respect.
- Be pro-active and flexible and take ownership of your learning experience as individuals and as a group. The experiential model of learning requires that you look forward and back across the semester. The logistics of our time in each country means that coursework will not always develop in a strictly linear fashion.
- Electronic devices: The use of phones, tablets and laptops are not permitted during site visits and guest lectures. We will discuss the need for the use of technology during this course.

Please refer to the SIT Student Handbook for policies on academic integrity, ethics, warning and probation, diversity and disability, sexual harassment, and the academic appeals process.

Course Schedule

LAUNCH, SAN FRANCISCO

Session 1, Dr. Wil Burns: *An Overview of the Science of Climate Change*

This class provides an overview of the science of anthropogenic global warming. Topics will include an explanation of the natural and anthropogenically-enhanced greenhouse effect, the role of general circulation models in projecting future climatic change, and current and potential impacts of climate change on ecosystems and human institutions.

Required Readings:

- 1.1 - Intergovernmental Panel on Climate Change (IPCC): "Climate Change 2013: The Physical Science Basis," pp. 4-28 (2013)
- 1.2 - Intergovernmental Panel on Climate Change (IPCC): "Global Warming of 1.5C (Summary for Policymakers)" (2018)
- 1.3 - "Skeptical Science, Most Used Climate Myths" (review the first 10 myths and responses on the right frame) (<https://thewire.in/17398/ten-inconvenient-truths-about-the-paris-climate-accord/>)
- 1.4 - Forsberg, A. (2015), San Francisco Climate Change Distance-Learning Module

Required Viewing:

Video part 1: Alan Forsberg: What is Climate Change? Introduction to Climate Science

Recommended:

- 1.5 - "Climate Literacy: The Essential Principles of Climate Science; A climate-oriented approach for learners of all ages" (http://cpo.noaa.gov/sites/cpo/Documents/pdf/ClimateLiteracyPoster-8_5x11_Final4-11.pdf)

Session 2, Dr. Wil Burns: *Overview of Global Climate Change Policymaking: International Perspectives*

This class provides an overview of international climate change policymaking. Topics include discussion of the key provisions of the United Nations Framework Convention on Climate Change and the Kyoto Protocol, the Paris Agreement and assessment of the current status of the Paris Agreement.

Required Readings:

- 2.1 - Betsill, M. (2014). International Climate Change Policy: Complex Multi Level Governance. In Regina Axelrod and Satcy VanDeveer (eds.), *The Global Environment: Institutions, Law, and Policy*, pp. 234-258. Los Angeles: Sage
- 2.2 - Keohane & Oppenheimer, *Paris: Beyond the Climate Dead End through Pledge and Review?*, 4(3) *Policy & Governance* 142-151 (2016)
- 2.3 - Manguiat, M. S., & Raine, A. (2018). Strengthening National Legal Frameworks to Implement the Paris Agreement. *Carbon & Climate Law Review*, 12(1), 15-22.

Required Viewing:

Video part 2, Alan Forsberg: Introduction to Climate Change Mitigation & Adaptation

Recommended Reading:

- 2.4 - Wold, Hunter & Powers (2009). Ch. 4: The UN Framework Convention on Climate Change. In *Climate Change and the Law*. LexisNexis.
- 2.5 - Surya Sethi, "Ten Inconvenient Truths About the Paris Climate Accord," *The Wire*, Dec. 16, 2015, <http://thewire.in/2015/12/16/ten-inconvenient-truths-about-the-paris-climate-accord-17398/>
- 2.6 - Meinhard Doelle, "The Paris Climate Agreement: Historic Breakthrough in Spite of Shortcomings," *Dalhousie University blogs*, Dec. 13, 2015, <https://blogs.dal.ca/melaw/2015/12/13/the-paris-climate-agreement-historic-breakthrough-in-spite-of-shortcomings/>
- 2.7 - "Analysis: The final Paris climate deal," Carbon Brief: Clear on Climate, Dec. 12, 2016, <https://www.carbonbrief.org/analysis-the-final-paris-climate-deal>
- 2.8 - U.S. Environmental Protection Agency (2015), [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013. Executive Summary.](#)

Session 3, Dr. Wil Burns: *Into the Great Wide Open? The Potential Promise, and Potential Perils, of Climate Geoengineering*

The feckless response of the world community to climate change has led to increasing attention to a suite of potential climate response options that fall under the rubric of "climate geoengineering," defined by the United Kingdom's Royal Society as "the deliberate large-scale manipulation of the planetary environment to counteract anthropogenic climate change." While climate geoengineering approaches could potentially help us to avoid passing critical climatic thresholds, many of them are also fraught with risk, and could produce winners and losers. This session will discuss the exigencies driving interest in climate geoengineering options, outline the primary categories of geoengineering and examples of geoengineering technologies, and assess potential benefits and risks of these approaches. Finally, we will discuss how climate geoengineering research and/or deployment might be governed at the international and national levels.

Required readings:

- 3.1 - Anderson, K., & Peters, G. (2016). The trouble with negative emissions. *Science*, 354(6309), 182-183.
- 3.2 - Burns, W. and Nicholson, S. (2016) Governing Climate Engineering. In Nicholson, S., & Jinnah, S. (eds.). *New Earth Politics: Essays from the Anthropocene*. MIT Press, pp. 343-358.

Recommended readings:

- 3.3 - Reynolds, J. (2016). Climate engineering and international law. In Farber, D. A., & Peeters, M. (eds.). *Climate Change Law*. Edward Elgar Publishing, pp. 178-188.

Session 4, Dr. Mike Mastrandrea: *Climate Policy in the United States and California*

This class will provide a primer on key climate policy mechanisms and introduce students to evolving state-level climate policy in California and its relationship to US Federal policy developments in the Obama and Trump eras. Students will learn about regulatory vs. market-based policies, the interaction between multiple policies within and across jurisdictions, and the role of administrative agencies in implementing climate policy.

Required Readings:

- 4.1 - David Roberts, California's cap-and-trade system may be too weak to do its job. *Vox* (Dec. 12, 2018).
<https://www.vox.com/energy-and-environment/2018/12/12/18090844/california-climate-cap-and-trade-jerry-brown>
- 4.2 - John Larsen et al., Taking Stock 2018. Rhodium Group (June 28, 2018). <https://rhg.com/research/taking-stock-2018/>
- 4.3 - Hiroko Tabuchi, The Oil Industry's Covert Campaign to Rewrite American Car Emissions Rules. *The New York Times* (Dec. 13, 2018).
- 4.4 - Juliet Eilperin and Brady Dennis, Major automakers strike climate deal with California, rebuffing Trump on proposed mileage freeze. *The Washington Post* (July 25, 2019).

Recommended:

- 4.5 - California Air Resources Board, California's 2017 Climate Change Scoping Plan: Executive Summary. https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017_es.pdf
- 4.6 - Elizabeth Shogren, Obama's Climate Legacy Will Be Harder to Undo Than Trump Thinks. *Mother Jones* (Jan. 7, 2017).
<https://www.motherjones.com/environment/2017/01/obama-climate-change-legacy-west/>
- 4.7 - David Bookbinder, Obama had a chance to really fight climate change. He blew it. *Vox* (Apr. 27, 2017). <https://www.vox.com/the-big-idea/2017/4/28/15472508/obama-climate-change-legacy-overrated-clean-power>

VIETNAM

Session 5, Dr. Nguyen Ngoc Huy: *Climate Change Impacts in Vietnam*

This class provides an overview of climate change impacts in Vietnam. The emphasis will be on climate projections and hazards assessments existing for Vietnam. The class highlights why Vietnam is regarded as one of the top 10 countries most vulnerable to climate change in the world. Material covered includes recorded climate changes in the past, as well as future projections, for factors such as rainfall, temperature and dynamics of natural hazards/disasters

(e.g. typhoon, drought, flood, flash flood), sea level rise. We will focus both on a national level as well as on hotspots at a regional scale where levels of climate change vulnerability are critical.

* NOTE: **Quiz 2** for the Distance-Learning Module # 2 on Vietnam is scheduled after this session

Required Readings:

- 5.1 - Ministry of Natural Resources and Environment (2009). Climate Change, Sea Level Rise Scenarios for Viet Nam. Retrieved from http://www.preventionweb.net/files/11348_ClimateChangeSeaLevelScenariosforVi.pdf
- 5.2 - Institute of Strategy and Policy on Natural Resources and Environment (2009) Viet Nam Assessment Report on Climate Change. Retrieved from http://www.unep.org/pdf/dtie/VTN_ASS_REP_CC.pdf
- 5.3 - Forsberg, A. (2015), Vietnam Climate Change Distance-Learning Module

Recommended Readings:

- 5.4 - Asian Development Bank (2013) Viet Nam: Environment and climate change assessment. Mandaluyong City, Philippines: Asian Development Bank, pgs. 1-35 (focus on 1-17). Retrieved from <http://www.adb.org/sites/default/files/institutional-document/33916/files/viet-nam-environment-climate-change.pdf>.

Session 6, Dr. Nguyen Viet Dung: *Institutional Framework in Responses to Climate Change in Vietnam: Roles of Civil Society in Policy-making*

This class will provide students with an overview of the political context and institutional framework of environmental governance and climate change policy process in Vietnam. Emphasis will be on the emerging engagement of civil society organizations (CSO) in the national policy process dealing with climate change adaptation and mitigation, particularly two examples given: The on-going REDD+ development (national level) and guidance on integration of climate change-responsive agriculture in local planning (local level).

Required Readings:

- 6.1 – Stephann Ortmann (2017). Environmental Governance in Vietnam: Institutional Reforms and Failures: Chapters 2,3,4
- 6.2 – Thiem H. Bui (2013). The Development of Civil Society and Dynamics of Governance in Vietnam's One Party Rule. *Global Change, Peace & Security*, 25:1, 77-93

Recommended Reading:

- 6.3 - Adger, W. N. (2000). Social and ecological resilience: are they related? *Progress in Human Geography*, 24(3), 347-364.
- 6.4 - Adger, W. N., Barnett, J., Brown, K., Marshall, N., & O'Brien, K. (2013). Cultural dimensions of climate change impacts and adaptation. *Nature Climate Change*, 3(2), 112-117.

Session 7, Dr. Le Chau Ha: *Changing Climate Patterns in Central Coast: Modeling Regional Climate and Hydrology*

This class introduces the region of the Central Coast of Vietnam based on scientific research and modeling, highlighting this region as one of the zones most vulnerable to climate changes in the country. The class provides an overview of natural and social characteristics, including climate regimes, of the central coastal region; presents and interprets significant climate changes

observed in the region from 1990 up to the present; and introduces the “river basin concept” for regional climate and hydrological modeling.

Required Readings:

- 7.1 - Keen, B., & Hoanh, C. T. (2015). Water resources in south-central coastal Vietnam: knowledge, management and research opportunities. *Sustainable and profitable crop and livestock systems in south-central coastal Vietnam*, Chapter 3 Section I (29-41).
- 7.2 - Brown, P. C. (2011). Livelihood Change around Marine Protected Areas in Vietnam: a Case Study of Cu Lao Cham. *Challenges of the Agrarian Transition in SE Asia Project*, Working Paper #16.
- 7.3 - Stephen J. Leisz: “Farming System Transitions in Vietnam's North Central and Northern Mountains: Systems’ Resiliency and Farmer Vulnerability.” Colorado State University.
- 7.4 - Schultz, M. and Avitabile, V. “2001-2005-2010 Land Cover Change analysis of the Vu Gia Thu Bon river basin, central Vietnam.” Land Use and Climate Change Interactions in Vietnam (LUCCI), Technical Report.
- 7.5 - “Vulnerability, Risk Reduction, and Adaptation to Climate Change - Vietnam.” *Climate Risk and Adaptation Country Profile*. Global Facility for Disaster Reduction and Recovery (GDFRR), April 2011. Pp. 1-16.

Recommended Readings:

- 7.7 - Tran Thuc (2010) Impacts of Climate Change on Water Resources in the Huong River Basin and Adaptation Measures. *VNU Journal of Science, Earth Sciences* 26 (2010) 210-217. Retrieved from http://js.vnu.edu.vn/khtd_4_10/4.pdf.
- 7.8 - CDKN. *Land use, Food Security and Climate Change in Vietnam* (2012). Retrieved from <http://cdkn.org/wp-content/uploads/2012/01/Land-Use-Food-Security-Climate-in-Vietnam-Policy-Brief.pdf>

Session 8, Mr. Nguyen Viet Dung: *Ethic Minority and Land allocation in Vietnam: Advancing / Retaining Social Safeguards in Reformed Forest- Climate Change Policies*

This class provides students with the recent development of forestland tenure with reference to securing community rights, particularly for ethnic minorities, through processes of reforming national forestry and climate change policies. This presents transformative strategies that safeguard rights of local communities in access to natural resources through forestland allocation as well as enable benefit-sharing based on community engagement in implementation of internationally-driven forestry initiatives. In summary, this class will help students understand opportunities and challenges of facilitating and advocating social safeguards towards ethnic minorities as a motive that contributes to good governance of natural resources and sustainable development in Vietnam.

Required readings:

- 8.1 - Ingalls, M.L., et al. 2018. State of Land in Vietnam: Growth and Institutions at a Crossroads. State of Land in the Mekong Region. Centre for Development and Environment, University of Bern and Mekong Region Land Governance. Bern, Switzerland and Vientiane, Lao PDR, with Bern Open Publishing; page 155-176 (source: <https://mrlg.org/wp-content/uploads/2019/05/Mekong-State-of-Land-May2019-with-New-map-MQ.pdf>)
- 8.2 - FAO and MRLG. 2019. Challenges and opportunities of recognizing and protecting

customary tenure systems in Viet Nam. Bangkok, 12 pp. Licence: CC BY-NC-SA 3.0 IGO.

Recommended readings:

8.3 – Pamela McElwee, Van Hai Thi Nguyen, Dung Viet Nguyen, Nghi Huu Tran, Hue Van Thi Le, Tuyen Phuong Nghiem and Huong Dieu Thi Vu (2016). Using REDD+ Policy to Facilitate Climate Adaptation at the Local Level: Synergies and Challenges in Vietnam. *Forests*, 8, 11.

MOROCCO

Session 9, Dr. Kenza Khomsi: *Climate Change, Consequences and Actions (Morocco and MENA Region)*

This class will provide an overview of climate change impacts for the countries of the Mediterranean and North Africa (MENA) region, with an emphasis on Morocco. The class will then mainly focus on understanding the key challenges and the potential pathways the country has chosen in order to adapt to Climate Change and build a sustainable economic development that is also socially inclusive and environmentally sustainable.

Required Readings:

- 9.1 - MOROCCO NATIONALLY DETERMINED CONTRIBUTION UNDER THE UNFCCC, 2016
(<http://www4.unfccc.int/ndcregistry/PublishedDocuments/Morocco%20First/Morocco%20First%20NDC-English.pdf>)
- 9.2 - Donat, M. G., et al. (2014) *Changes in Extreme Temperature and Precipitation in the Arab Region: Long-Term Trends and Variability Related to ENSO and NAO*. *International Journal of Climatology* 34: 581-592. doi: 10.1002/joc.3707.
- 9.3 - Forsberg, A. (2015), Morocco Climate Change Distance-Learning Module

Recommended Readings:

- 9.4 - Khomsi, K., Mahe, G., Trambly, Y., Sinan, M., and Snoussi, M.: Regional impacts of global change: seasonal trends in extreme rainfall, run-off and temperature in two contrasting regions of Morocco, *Nat. Hazards Earth Syst. Sci.*, 16, 1079-1090, <https://doi.org/10.5194/nhess-16-1079-2016>, 2016.
- 9.5 - Ministry Delegate of the Minister of Energy, Mines, Water and Environment, in charge of Environment (2014) *Moroccan Climate Change Policy*. Retrieved from <http://www.4c.ma/medias/MCCP%20-%20Moroccan%20Climate%20Change%20Policy.pdf>
- 9.6 - Sowers, J., Vengosh, A., & Weinthal, E. (2011). Climate Change, Water Resources, and the Politics of Adaptation in the Middle East and North Africa. *Climatic Change*, 104(3-4), 599-627.

Session 10, Guest Speaker, Rachid Tahiri, Ministry of the Environment: *The Moroccan Experience in Global Climate Change Negotiations*

BOLIVIA

Session 11: Prof. Tania Ricaldi Arévalo: *Climate Change Policies in Bolivia*

This class will present the central aspects of climate change policies in Bolivia, the progress made in terms of national regulations, national mechanisms and their links with the

international context. The analysis of the financing and budget assigned to climate change will also be presented, as one of the factors that shows the prioritization of policies in the face of climate change.

Required Readings:

- 11.1 - Law of the Rights of Mother Earth, 2012. (Please read all ten articles)
<http://www.worldfuturefund.org/Projects/Indicators/motherearthbolivia.html>
- 11.2 - Manifiesto of the Isla del Sol: "Save Our Mother Earth to Save Life", 2015. (Please read pages 1-11) (only available online)
<http://www.planificacion.gob.bo/uploads/webingles/index.html#p=1>
- 11.3 - Intended Nationally Determined Contribution (INDC) from the Plurinational State of Bolivia (Oct 12, 2015) (Please read all 17 pages)
<http://www.planificacion.gob.bo/uploads/2.INDC-BOLIVIA-English%20%28doc%29.pdf>
- 11.4 - Executive Summary of the Second National Communication of the Plurinational State of Bolivia, 2009. (please read the first ten pages 42-52)
<http://unfccc.int/resource/docs/natc/bolnc2exsume.pdf>

Recommended Readings:

- 11.5 - Economic and Social Development Plan 2016-2020 within the framework of integrated development for Living Well (Please read pp. 67-70, 140-151 and 168-177) (Spanish only)
http://www.planificacion.gob.bo/uploads/PDES_INGLES.pdf
- 11.6 - Análisis de flujos de Financiamiento Internacional y Presupuesto Nacional para el Cambio Climático, 2015. (Spanish only) <http://lidema.org.bo/wp-content/uploads/2016/12/Financiamiento-internacional-y-presupuesto-nacional-para-el-cambio-clim%C3%A1tico.pdf>
- 11.7 - Ricaldi, T. (2017) Políticas de cambio climático en Bolivia. Las contradicciones y los desencantos, en Lógicas de desarrollo, extractivismo y cambio climático, De La Fuente, M, Ricaldi, T. y Saldomando, A. CESU-UMSS, Reinventerra, 259-290 (Spanish only)

Session 12, by Prof. Alan Forsberg: *Climate Systems and Water in the Andes*

This class reviews systems analysis and relates these concepts to the climate dynamics and processes at work in the Tropical Andes, with a special focus on the role of water in moderating climate.

Key concepts include: Inputs, outputs, equilibrium, feedback, emergence, system dynamics, energy and matter systems, properties of water, latent heat, specific heat, glacier systems, watershed systems, monsoon systems

Required Readings:

- 12.1 - Review: Forsberg, A., (2018) San Francisco Climate Change Distance-Learning Module - Systems Theory and Climate Dynamics
- 12.2 - Review: Forsberg, A., (2018) Vietnam Climate Change Distance-Learning Module – Earth’s Climate System part 1
- 12.3 - Complete: Forsberg, A., (2018) Bolivia Climate Change Distance-Learning Module – Bolivia’s Many Climates

12.4 - Kolata, A. L., (1993). The Technology of Raised Field Agriculture. In *The Tiwanaku: Portrait of an Andean Civilization*, 183-190. Blackwell Publishers.

12.5 – Kolata, A. L., (1993). Chapter 8: The Decline and Fall of Tiwanaku. In *The Tiwanaku: Portrait of an Andean Civilization*, 282-292. Blackwell Publishers.

Recommended Readings:

12.6 - Hoffmann, Dirk. A Lake in Bolivia Dries Up. Glacier Hub, Feb. 25, 2016:

<http://glacierhub.org/2016/02/25/a-lake-in-bolivia-dries-up/>

12.7 - M.B. Bush, J.A. Hanselman, and W.D. Gosling (2010). Nonlinear Climate Change and Andean Feedbacks: An Imminent Turning Point? *Global Change Biology*, 1-10.

<http://www.westfield.ma.edu/uploads/GCBstudy.pdf>

Guide and Guest Speaker in Tiwanaku: Prof. Osvaldo Rivera: *Climate Change and the Tiwanaku*

This talk is about how the Tiwanaku used water and solar energy to stabilize an inhospitable climate at high altitude and create an incredibly productive agro-ecological system. While that system served as the primary economic base for the region's most advanced civilization over centuries, it was climate change that proved to be the downfall of the Tiwanaku.

Session 13, by Prof. Alan Forsberg: *Climate Change Impacts in Bolivia Past, Present, and Future*

This class will help students get to know and understand past, present and future impacts of climate change in Bolivia with a special emphasis on changes in the hydrologic cycle and its implications for climate stability and water resources.

Required Readings:

13.1 - Vuille, Mathias. Climate Change and Water Resources in the Tropical Andes, IADB Working Paper, March 2013

<http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=37571430>

13.2 - Review: Forsberg, A., (2018) Bolivia Climate Change Distance-Learning Module – Bolivia's Many Climates - sections on Ocean Currents and Climate, Ocean Currents and Atmospheric Circulation, the Walker Cell, El Niño.

Recommended Readings:

13.3 - IPCC Fifth Assessment Report AR5 – WG II – Ch. 27: Central and South America
https://ipcc-wg2.gov/AR5/images/uploads/WGIIAR5-Chap27_FINAL.pdf

13.4 - Seiler, Christian; Hutjes, Ronald W.A. & Kabat, Pavel. Climate Variability and Trends in Bolivia. *Journal of Applied Meteorology and Climatology*, Vol 52, Jan 2013
<http://journals.ametsoc.org/doi/pdf/10.1175/JAMC-D-12-0105.1>

13.5 - M. W. Binford, A.L. Kolata, M. Brenner, J. M. Janusek, M. T. Seddon, M. Abbott, J. H. Curtis (1997). Climate Variation and the Rise and Fall of an Andean Civilization. *Quaternary Research*, Vol.47, No.2, 235-248.

13.6 - Hoffmann, Dirk & Requena, Cecilia. "Bolivia in a 4 degree warmer world. Socio-political scenarios in the face of climate change for the years 2030 and 2060 in the Northern Altiplano", executive summary, La Paz, 2012.

Session 14, by Prof. Alan Forsberg: *Dealing with Climate Change in the Tropical Andes: Tapping both Traditional Indigenous and Modern Scientific Knowledge*

This class explores the strengths and shortcomings of scientific climate models and indigenous knowledge. We then explore possible adaptation measures and responses to changing social and environmental conditions brought about by future climate change.

Required Readings:

- 14.1 - *Don't Break the Heart of Mother Earth*, Essay by Alan Forsberg – 2015
- 14.2 - C. Valdivia, A. Seth, J. L. Gilles, M. Garcia, E. Jimenez, J. Cusicanqui, F. Navia, and E. Yucra, (2010). Adapting to Climate Change in Andean Ecosystems: Landscapes, Capitals, and Perceptions Shaping Rural Livelihood Strategies and Linking Knowledge Systems. *Annals of the Association of American Geographers*, 100(4) 2010, pp. 818–834
- 14.3 – Boillat, S. and Berkes, F. (2013). Perception and Interpretation of Climate Change among Quechua Farmers of Bolivia: Indigenous Knowledge as a Resource for Adaptive Capacity. *Ecology and Society*, 18(4): 21.
- 14.4 - Review: Forsberg, A., (2018) Morocco Climate Change Distance-Learning Module
- 14.5 - Review: Forsberg, A., (2018) Bolivia Climate Change Distance-Learning Module 4

Recommended Readings:

- 14.6 - CDKN. Building resilience to climate change through indigenous knowledge: The case of Bolivia, March 2013
http://cdkn.org/resource/building-resilience-to-climate-change-through-indigenous-knowledge-the-case-of-bolivia/?loclang=en_gb

Reviews for the Final Exam:

Tuesday, December 3: Review of Climate Change Science by Prof. Alan Forsberg –
***Please email me questions from the final study guide by no later than 6 p.m. the night before so I can do my best to help you.**

Wednesday, December 4: Final Exam - Questions will consist of true/false, multiple choice, fill in the blank, short answer, and one essay question.