

PATRICK A. RAY

Research Assistant Professor

University of Massachusetts, Department of Civil and Environmental Engineering

18 Marston Hall, 130 Natural Resources Road

Amherst, MA 01003-9293

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EDUCATION

Postdoc: Water Systems Modeling under Uncertainty, UMass Amherst, 2013-2014

Product: *Confronting Climate Uncertainty in Water Resources Planning and Project Design: The Decision Tree Framework*

Adviser: Casey Brown

Ph.D.: Water Resources Engineering, Tufts University, 2010

Dissertation: *Robust Optimization using a Variety of Performance Metrics - A Case Study of Water Systems Planning Under Climate and Demographic Uncertainty in Amman, Jordan*

Advisers: Richard Vogel and Paul Kirshen

M.Sc.: Civil and Environmental Engineering, Water Resources, Tufts University, 2006

Thesis: *Least-cost Optimization for Water Systems Planning - An Exploration of the Potential Applications of Alternative Technologies for Water Supply in Beirut, Lebanon*

Advisers: Richard Vogel and Paul Kirshen

B.Sc.: Civil and Environmental Engineering, UMass Amherst, 2001

Honors Thesis: *Hydrogenotrophic Denitrification of Drinking Water Using a Dead-End Hollow-Fiber Membrane Bioreactor*

Adviser: Sarina Ergas

HONORS/AWARDS

World Bank Knowbel Prize Team Award, 2015

Professor of the Year, Faculty of Engineering, Middle East University, 2011

Fulbright Fellowship, Jordan, 2008-2009

National Science Foundation Graduate Research Fellowship, 2004-2007

Earle F. Littleton Award and Scholarship, Tufts University Civil Engineering Department, 2006

Tufts Institute for the Environment Research Scholarship, 2004

Tufts University Fares Center Research Grant, 2004

Tufts University WaterSHED Fellowship, 2003

Commonwealth Scholar & Departmental Honors Recipient, *Summa Cum Laude*, 2001

President, Tau Beta Pi National Engineering Honor Society, UMass Amherst Chapter, 2000

William W. Boyer Endowed Scholarship, 2000

College of Engineering Alumni Scholarship, 2000

University of Massachusetts Honors Research Project Fellowship, 2000

PUBLICATIONSPUBLICATIONS IN PREPARATION

- Ray, P.A., Bonzanigo, L., Wi, S., Yang, Y.E., Karki, P., Brown, C.M., Garcia, L.E., Rodriguez, D.J. (2016). "Assessment of resilience of hydropower investment to climate, geophysical and economic uncertainty." *In Preparation*.
- Ray, P., Wi, S., Schwarz, A., Correa, M., Brown, C. (2016). "Drought vulnerability assessment of complex water systems: Demonstration for the California Department of Water Resources." *In Preparation*.
- Ray, P., Pitois, G., Zhu, T., Robertson, R., Steinschneider, S., Brown, C. (2016). "The effects of variations in El Niño and La Niña patterns on global food production." *In Preparation*.

REFEREED JOURNAL PUBLICATIONS

- Taner, M. Ü., Ray, P. A., Brown, C. M. (2016). "Robustness-based evaluation of water infrastructure design under climate change." *Climatic Change*, Under Review.
- Yang, Y. E., Wi, S., Ray, P. A., Brown, C. M., and Khalil, A. F. (2016). "Modeling water resources of the Brahmaputra River under future climate and social uncertainties." *Global Environmental Change*, 37, 16-30, doi:10.1016/j.gloenvcha.2016.01.002.
- Ray, P. A., Yang, Y. E., Wi, S., Khalil, A. F., Chatikavanij, V., Brown, C. M. (2015). "Room for improvement: Hydroclimatic Challenges to Poverty-reducing Development of the Brahmaputra River." *Environmental Science and Policy*, 64-80, doi: 10.1016/j.envsci.2015.06.015.
- Yang, Y. E., Ray, P. A., Brown, C. M., Khalil, A. F., Yu, W. H. (2015). "Estimation of flood damage functions for river basin planning: A case study in Bangladesh." *Natural Hazards*, 75(3), 2773-2791, doi: 10.1007/s11069-014-1459-y.
- Ray, P. A., Watkins Jr., D. W., Vogel, R. M., Kirshen, P. H. (2014). "Performance-Based Evaluation of an Improved Robust Optimization Formulation." *Journal of Water Resources Planning and Management-Asce*, 140(6), doi: 10.1061/(ASCE)WR.1943-5452.0000389.
- Ray, P. A., Kirshen, P. H., Watkins Jr., D. W. (2012). "Staged Climate Change Adaptation Planning for Water Supply in Amman, Jordan." *Journal of Water Resources Planning and Management-Asce*, 138(5), 403-411, doi: 10.1061/(ASCE)WR.1943-5452.0000172.
- Ray, P. A., Kirshen, P. H., Vogel, R. M. (2010). "Integrated Optimization of a Dual Quality Water and Wastewater System." *Journal of Water Resources Planning and Management-Asce*, 136(1), 37-47, doi: 10.1061/ASCEWR.1943-5452.0000004.

BOOKS AND THESES/DISSERTATIONS

- Ray, P., and Brown, C. (2015). "Confronting Climate Uncertainty in Water Resources Planning and Project Design: The Decision Tree Framework." Washington, DC: World Bank, doi:10.1596/978-1-4648-0477-9.
- García, L. E., Matthews, J. H., Rodriguez, D. J., Wijnen, M., DiFrancesco, K. N., Ray, P. A. (2014). "Beyond Downscaling: A Bottom-Up Approach to Climate Adaptation for Water Resources Management." *World Bank Group*. Washington, D. C. <https://openknowledge.worldbank.org/handle/10986/21066> License: CC BY 3.0 IGO.
- Ray, P. (2014). "Water systems planning under uncertainty in Amman, Jordan: An application of robust optimization techniques to water resources sustainability." Scholars' Press, ISBN: 978-3-639-66254-2.
- Ray, P.A. (2010). "Robust Optimization Using a Variety of Performance Measures: A Case Study of Water Systems Planning Under Climate and Demographic Uncertainty in Amman, Jordan." PhD

Dissertation, Tufts University, Department of Civil and Environmental Engineering, Medford, MA.

Ray, P. A. (2006). "Least-Cost Optimization for Water Systems Planning: An Exploration of the Potential Applications of Alternative Technologies for Water Supply in Beirut, Lebanon." MS Thesis, Tufts University, Department of Civil and Environmental Engineering, Medford, MA, 1-214.

Ray, P.A. (2001). "Hydrogenotrophic Denitrification of Drinking Water Using a Dead-End Hollow-Fiber Membrane Bioreactor." Honors Thesis, University of Massachusetts, Department of Civil and Environmental Engineering, Amherst, MA, 1-88.

PROFESSIONAL REPORTS

Bonzanigo, L., Brown, C., Harou, J., Hurford, A., Karki, P., Newmann, J., Ray, P. (2015). "South Asia investment decision making in hydropower: Decision tree case study of the Upper Arun Hydropower Project and Koshi Basin Hydropower Development in Nepal." GEEDR South Asia, The World Bank. Report No.: AUS 11077.

For the World Bank Group (Feb 2014). *State of the Brahmaputra River Basin: Hydro-climate and Anthropocentric Water Systems*.

For the World Food Program and Vision Hope International (July 2012). *Designs for WASH-Related Labor-Intensive Food-for-Work Projects in Hajja and Hodeidah, Yemen*.

For the Millennium Challenge Corporation and the Ministry of Water of the Hashemite Kingdom of Jordan (July 2010). *Zarqa Governorate Wastewater System Reinforcement and Expansion Preliminary Engineering & Feasibility Study Report: Volume II, Feasibility: Chapter 4 Economic Analysis*.

For the United Nations Development Program (May 2011): *Jordan's 3rd National Communication to the United Nations Framework Convention on Climate Change (UNFCCC)*, including the *National Self Assessment* evaluating the current state of climate change vulnerability and adaptation in Jordan, and a critical assessment of the gaps/constraints in Jordan's institutions, finances and policies.

For Minister of Water of the Hashemite Kingdom of Jordan (10 October 2010). *DISI Pump Station Report on Concerns Related to the Installation of the Disi Aquifer Water Pumping Station at the Site of the Middle East University, Amman, Jordan*.

CONFERENCE PRESENTATIONS, WORKSHOPS, INVITED TALKS

Ray, P. A. (2016). "Decision Meeting South Asia: Impacts of Climate Risks on Water, Hydro." World Bank Water Week, Washington, D.C., 7 April.

Ray, P. A., and Brown, C. M. (2016). "Climate Impacts in Water and a Framework for Mainstreaming Climate Resilience in Water Programs and Investments." World Bank Water Week, Washington, D.C., 5 April.

Government of the Republic Of Kenya Ministry Of Environment, Water and Natural Resources (29 Feb – 1 Mar 2016). "Results of Decision Tree Phase III and Workshop on Phase IV of Decision Tree Analysis for Mwache Dam." Second Regional Water Resources Planning and Climate Risk Assessment Workshop, Kwale County, Kenya.

Organismo de Cuenca Aguas del Valle de México, OCAVM (25 February 2016). "Utilización del Árbol de Decisión en el Desarrollo del Plan Integral de Gestión del Sistema Cutzamala: Actualizar y Resultados de Análisis de Datos." Mexico City, Mexico.

Sistema de Aguas de la Ciudad de México, SACMEX (22-23 February 2016). "La Utilidad Potencial Del Decision Tree Framework Para El Sistema de Aguas de la Ciudad de México." Mexico City, Mexico.

- Ray, P. (2016). "Confronting Climate Uncertainty in Water Resources Planning and Project Design." 3rd Annual McMaster Spring Water Forum, Hamilton, Ontario, Canada, 18 April.
- Karki, P., Ray, P. (2016). "Climate Change and Disaster Risk Management in Hydropower: Building Resilience." 47th Annual H.G. Acres Seminar, Niagara Falls, Ontario, Canada, 14 April.
- Ray, P., Schwarz, A., Wi, S., Correa, M., Brown, C. (2015). "Evaluating options for improving California's drought resilience." Proceedings of the American Geophysical Union 2015 Fall Meeting, San Francisco, CA, 14-18 December.
- Wi, S., Yang, Y. E., Ray, P., Brown, C. (2015). "Modular modeling system for building distributed hydrologic models with a user-friendly software package." Proceedings of the American Geophysical Union 2015 Fall Meeting, San Francisco, CA, 14-18 December.
- Ray, P., Bonzanigo, L., Taner, U., Wi, S., Yang, Y.C.E., Brown, C. (2015). "Lessons learned from applications of a climate change decision tree to water system projects in Kenya and Nepal." Proceedings of the American Geophysical Union 2015 Fall Meeting, San Francisco, CA, 14-18 December.
- Bonzanigo, L., Brown, C., Harou, J., Hurford, A., Ray, P. (2015). "A decision making under uncertainty approach to identifying efficient and robust hydropower investment portfolios in the Koshi Basin, Nepal." Third Annual Workshop on Decision Making Under Deep Uncertainty, Deltares, Delft, Netherlands, 3-5 November.
- Van Beek, E., Ray, P., Haasnoot, M., Kwadijk, J. (2015). "Decision Tree Framework and Dynamic Adaptive Policy Pathways – how can they complement each other in managing uncertainty in hydropower projects." Third Annual Workshop on Decision Making Under Deep Uncertainty, Deltares, Delft, Netherlands, 3-5 November.
- Organismo de Cuenca Aguas del Valle de México, OCAVM (26 October 2015). "La Utilidad Potencial Del Decision Tree Framework Para El Desarrollo Del Plan Integral De Gestión Del Sistema Cutzamala: Propuesta." Mexico City, Mexico.
- Tufts University CEE 291 Graduate Program Seminar (15 September 2015). "Climate change risk assessment and management: Toward a reproducible framework." Environmental and Water Resources Engineering (EWRE) and Water: Systems, Science and Society (WSSS) Fall Seminar Series. Medford, Massachusetts.
- Government of the Republic Of Kenya Ministry Of Environment, Water and Natural Resources (11 August 2015). "Tools for water resources management." Regional Water Resources Planning and Climate Risk Assessment Workshop, Kwale County, Kenya.
- Government of the Republic Of Kenya Ministry Of Environment, Water and Natural Resources (11 August 2015). "Decision Tree framework." Regional Water Resources Planning and Climate Risk Assessment Workshop, Kwale County, Kenya.
- Government of the Republic Of Kenya Ministry Of Environment, Water and Natural Resources (12 August 2015). "Decision Tree examples." Regional Water Resources Planning and Climate Risk Assessment Workshop, Kwale County, Kenya.
- World Bank Consultants Workshop (22 June 2015). "The application of the Decision Tree Framework to the Upper Arun Hydropower Project, Nepal." Managing uncertainty in hydropower and water projects. Washington, D.C.
- Taner, U. M., Ray, P. A., and Brown, C. M. (2015). "Vulnerability-Based Evaluation of Water Supply Design Under Climate Change." Proceedings of the European Geophysical Union General Assembly, Vienna, Austria, 12-17 April, EGU2015-8049.
- Brown, C. M., et al. (2015). "Climate Stress Testing to Reveal Vulnerabilities in Infrastructure Planning." Proceedings of the European Geophysical Union General Assembly, Vienna, Austria, 12-17 April, EGU2015-10202.

- Nepal Water and Energy Development Company (30 March 2015). "Upper Trishuli-1 Hydropower Facility Climate Change Risk Assessment: Summary of Inception Report." PRP Experts Nepal UT-1 Project Visit. Kathmandu, Nepal.
- Ray, P. A., Robertson, R., Zhu, T., Pitois, G., Steinschneider, S., and Brown, C. (2014). "The Effects of Variations in El Niño and La Niña Patterns on World Food Markets." Proceedings of the American Geophysical Union 2014 Fall Meeting, San Francisco, CA, 15-19 December.
- World Bank Group (12 December 2014). "Decision Tree: Case Study of the Upper Arun Hydropower Facility in Nepal." Review meeting on the progress status of programmatic approach (PA) to impacts of climate change on water and hydropower. Washington, DC.
- Ray, P. A., Wi, S., Schwarz, A., Correa, M., Brown, C. M. (2014). "A drought vulnerability analysis of California's Central Valley Project." Second Annual Workshop on Decision Making Under Deep Uncertainty, RAND Corporation, Santa Monica, CA, 18-19 November.
- National Socio-Environmental Synthesis Center (8 October 2014). "Decision Support Framework for Evaluation of Climate Risk to Water Resource Systems." SESYNC Office, Annapolis, Maryland.
- World Bank Group (10 September 2014). "Decision Support Framework for Evaluation of Climate Risk to Water Resource Systems." Seminar on Impacts of Climate Change on Investments in Water Resources and Hydropower Projects. Yak and Yeti Hotel, Kathmandu, Nepal.
- World Bank Group (9 September 2014). "Tools for Water Resources Management." Training workshop on understanding the link between hydrological and climate change modeling. Yak and Yeti Hotel, Kathmandu, Nepal.
- World Bank Group (9 September 2014). "Decision Support Framework for Evaluation of Climate Risk to Water Resource Systems." Training workshop on understanding the link between hydrological and climate change modeling. Yak and Yeti Hotel, Kathmandu, Nepal.
- Ray, P. A., and Brown, C. M. (2014). "Decision Support Framework for Evaluation of Climate Risk to Water Resource Systems." Stockholm World Water Week, 31 August - 5 September.
- World Bank Group (24 June 2014). "Decision Support Framework for Evaluation of Climate Risk to Water Resource Systems." Washington, DC.
- USAID Climate Smart Food Security Symposium (23 July 2014). "Adapting to Climate Impacts on Water for Agriculture." USAID, Washington, DC.
- Ray, P. A., Taner, M. Ü., and Brown, C. M. (2014). "Downscaled GCMs and a Weather Generator – Capacity Effects for a Hydro Plant in Malawi." Proceedings of the Water Systems, Science, and Society Under Global Change: UCOWR / NIWR / CUAHSI Annual Conference, Tufts University, Medford, MA, 18-20 June.
- Ray, P. A., and Brown, C. M. (2014). "Decision support framework for evaluation of climate risk to water resource systems." Proceedings of the American Society of Civil Engineers 2013 World Water and Environmental Resources Congress, Portland, OR, 1-5 June.
- Yang, Y. E., Ray, P. A., Wi, S., Brown, C. M. (2014). "Climate change risk on water resources management of Himalaya basins." Proceedings of the American Society of Civil Engineers 2013 World Water and Environmental Resources Congress, Portland, OR, 1-5 June.
- Fifth Annual WSSS Symposium Regional Planning Panel (11 April 2014). "Regional planning: A look at the Brahmaputra and some ideas for planning under uncertainty." Tufts University Jaharis Family Center for Biomedical and Nutritional Sciences, Boston, Massachusetts.
- Yang, Y. E., Ray, P. A., Brown, C. M., Khalil, A. F., Yu, W. H. (2014). "Estimation of flood affected area with various data and methods – A case study in Bangladesh." Proceedings of the 4th Workshop of the Global Flood Working Group, European Centre for Medium-Range Weather Forecasts, Reading, UK, 4-6 March.

- Yang, Y. E., Ray, P. A., Wi, S., Brown, C. M., Khalil, A. F., (2014). "Modeling the Brahmaputra River: Hydrology, hydropower, flooding and human systems." Proceedings of the Assam Water Conference and Internal Meeting, Guwahati, India, 3-7 February.
- Ray, P. A., Yang, Y. E., Wi, S., and C. M. Brown. (2013). "Future Visions of the Brahmaputra – Establishing Hydrologic Baseline and Water Resources Context." Proceedings of the American Geophysical Union 2013 Fall Meeting, San Francisco, CA, 9-13 December.
- World Bank Water Group Seminar (7 November 2013). "Module 2: Discussion of options for decision making under uncertainty." Washington, DC.
- Environmental and Water Resources Engineering Research Seminar Series (13 September 2013). "Between Iraq and a Hard Place: Seeking sustainable solutions to water resources stressors in Jordan (and other tricky spots)." University of Massachusetts, Amherst, Massachusetts.
- Ray, P. A. (2013). "Labor-Intensive Works Programs as a Sustainable and Efficient Model Water Resources Development: Case Study of Hajja and Hodeidah, Yemen." Proceedings of the American Society of Civil Engineers 2013 World Water and Environmental Resources Congress, Cincinnati, OH, 19-23 May.
- Liberal Arts and Critical Issues Seminar Series (10 October 2011). "Hearts and minds in the clash of civilizations." George Fox University, Newberg, Oregon.
- Peace and Justice Symposium (22 September 2011). "A story of my friendship with Arabs." George Fox University, Newberg, Oregon.
- Kirshen, P., Ray, P., and Watkins Jr., D. (2011) "Incorporating Climate Change into Long-Range Water Supply Planning Using Scenario Analysis and Stochastic Programming." AWRA 2011 Spring Specialty Conference: Managing Climate Change Impacts on Water Resources: Adaptation Issues, Options, and Strategies, Baltimore, MD, 18-20 April.
- Engineering Day Research Currents (12 April 2011). "Climate Change in Jordan." Middle East University, Amman, Jordan.
- German-Jordanian Academic Collaboration Seminar (7 March 2011). "Water in Jordan." Middle East University, Amman, Jordan.
- Leadership in Energy and Environmental Design (LEED) Seminar (14 December 2010). "Questions of scale: water infrastructure solutions in Amman, Jordan." Middle East University, Amman, Jordan.
- Ray, P. A., Vogel, R. M., Watkins Jr., D. W. (2010). "Robust optimization using a variety of performance indices." Proceedings of the American Society of Civil Engineers 2010 World Water and Environmental Resources Congress, Providence, RI, 16-20 May.
- Ray, P. A., Kirshen, P. H., Rosenberg, D. E., Hagan, R. E. (2010). "An overview of the water situation in Amman, Jordan." Proceedings of the American Society of Civil Engineers 2010 World Water and Environmental Resources Congress, Providence, RI, 16-20 May.
- Ray, P. A., and Kirshen, P. H. (2010). "Robust optimization of the water system in Amman, Jordan." Proceedings of the American Society of Civil Engineers 2010 World Water and Environmental Resources Congress, Providence, RI, 16-20 May.
- WSSS Holiday Celebration (9 December 2009). "Robust optimization of the water systems in Amman, Jordan, and Beirut, Lebanon." Tufts University, Medford, Massachusetts.
- Guest Lecture in Environmental and Water Resources Engineering Systems Class (13 March 2007). "Optimization of integrated water and wastewater system: Case study of Beirut, Lebanon." Tufts University, Medford, Massachusetts.
- Environmental and Water Resources Graduate Seminar (7 December 2006). "Case studies of Robust Optimization." Tufts University, Medford, Massachusetts.

- Ray, P. A., Kirshen, P. H., Vogel, R. M. (2006). "Optimization of integrated water and wastewater systems: Case study of Beirut, Lebanon." Proceedings of the American Society of Civil Engineers 2006 World Water and Environmental Resources Congress, Omaha, NE, 21-25 May. On Collaboration with the Faculty of Civil Engineering at the American University of Beirut, Lebanon (28 June 2005). "Least-cost optimization for water systems planning: An exploration of the potential applications of alternative technologies for water supply and disposal in Beirut, Lebanon." Beirut, Lebanon.
- WSSS Seminar Fall Series (Fall 2004). "Alleviating water stress in Beirut." Tufts University, Medford, Massachusetts.
- Environmental and Water Resources Graduate Seminar (Fall 2004). "Optimizing Beirut's water supply." Tufts University, Medford, Massachusetts.
- Environmental and Water Resources Graduate Seminar (Fall 2003). "Lebanon water reuse: A multi-objective optimization model." Tufts University, Medford, Massachusetts.

FUNDED PROPOSALS AND COMPETITIVE GRANTS

- California Department of Water Resources, *California Climate Risk: Evaluation of Climate Risks and Adaptation Options for California Department of Water Resources*, PI: Casey Brown, Co-PI: Patrick Ray, \$188,846, Start date: 9/1/2016
- US Army Corps of Engineers, *Decision Support Framework for Climate Change Risk Assessment and Risk Management*, PI: Patrick Ray, \$69,974, Start date: 6/5/2015
- World Bank Group, *Including Climate Uncertainty in Water Resources Planning and Project Design - Decision Tree Initiative - Pilot Studies*, PI: Patrick Ray, Co-PIs: Yi-Chen Yang, Sungwook Wi, Casey Brown, \$609,386, Start date: 3/13/2015

RESEARCH ADVISING EXPERIENCE

UNIVERSITY OF MASSACHUSETTS, AMHERST

PhD Committee Member

- Mehmet Umit Taner, Civil and Environmental Engineering, Water Resources Systems Analysis
- #### Master's Committee Member
- Kathryn Booras, Civil and Environmental Engineering, Water Resources Systems Analysis

ANNA UNIVERSITY, CHENAI, INDIA

PhD Committee Member

- R. Balamurugan, Civil and Environmental Engineering, "Visual Simulation and Optimization Model for Water Release from Vaigai Reservoir System," 2013.

MICHIGAN TECH UNIVERSITY, HOUGHTON, MICHIGAN

Master's Thesis Committee Member

- Patrick Spencer: graduate student in Peace Corps Master's International Program in Civil and Environmental Engineering, water system robust optimization model for rural/urban water tradeoff in Ethiopia, 2012-2013.

GEORGE FOX UNIVERSITY, NEWBERG, OREGON

Adviser for Undergraduate Research

- Gustavo Moreno-Vela, Richter Fellow: economic analysis of the effect of climate change on the viability of the pinot noir grape in the Willamette Valley, Oregon, 2012.
- Ryan Rudnick, Richter Fellow: rural water treatment solar distillation and UV treatment using low-cost renewable energy sources in Ethiopia, 2013.
- Servant Engineering and Senior Design: undergraduate theses related to global change and water resources engineering, including case studies in Colombia (biosand filtration), Thailand (solar distillation), east Africa (filtration technology improvement), and Oregon (Oregon Department of Fish and Wildlife tide gate re-design, rain garden design and implementation, sustainable living community feasibility study, streambed restoration, floodplain analysis, and watershed improvement), 2012-2013.

TEACHING EXPERIENCE

GEORGE FOX UNIVERSITY

- Water Resources Engineering (ENGC 350): Spring 2012, Spring 2013
- Geotechnical Engineering (ENGC 340): Spring 2012, Spring 2013
- Introduction to Environmental Engineering (ENGC 310): Fall 2011, Fall 2012
- Engineering Surveying (ENGC 320): Fall 2011, Fall 2012
- Engineering Senior Design (ENGR 481): Fall 2012
- Statistics for Engineers and Scientists (MATH 240): Fall 2012
- Engineering Economics (ENGR 485): Spring 2012

MIDDLE EAST UNIVERSITY

- Engineering Economics (Course Number 0902206): Fall 2010, Spring 2011
- Fluid Mechanics (Course Number 0902252): Spring 2011
- Numerical Methods for Engineers (Course Number 0902301): Spring 2011
- Hydraulics and Hydrology (Course Number 0902451): Fall 2010
- Statics (Course Number 0902201): Fall 2010

TUFTS UNIVERSITY – *teaching assistant*

- Hydraulics (CE 12): Fall 2003, Spring 2008
- Probability and Statistics (ES-56): Fall 2007
- River Hydraulics (CEE 131): Spring 2004, Fall 2007
- Civil Engineering Systems (CEE 114): Spring 2005

EMPLOYMENT RECORD

- | | |
|--|--------------|
| UNIVERSITY OF MASSACHUSETTS, AMHERST | 2014-present |
| Research Assistant Professor | |
| <ul style="list-style-type: none"> • Water systems planning and management • Hydro-economic analysis • Climate change adaptation • International development | |
| CLOUDWATER, LLC., AMHERST, MASSACHUSETTS | 2014-present |
| Associate | |
| <ul style="list-style-type: none"> • Water systems planning (water system modeling, economic analysis, climate and demographic change adaptation, capacity building) | |

- THE WORLD BANK GROUP, WASHINGTON, D.C. 2013-present
Independent Consultant
- Lead author in the development of a decision tree for incorporation of climate-related uncertainties into World Bank investments in the water sector.
- UNIVERSITY OF MASSACHUSETTS, AMHERST 2013-2014
Postdoctoral Research Associate
- Hydro-economic analysis of the Brahmaputra River for the World Bank
 - Analysis of relationship between global drought patterns and ENSO for the Global Water Partnership
 - Climate change robustness analysis of design capacity of a hydropower plant in Malawi
 - World Bank Decision Tree Initiative for including climate uncertainty in water resources planning and project design
- GEORGE FOX UNIVERSITY, NEWBERG, OREGON 2011-2013
Assistant Professor of Civil and Environmental Engineering
- Founder and Developer of Civil Engineering Program
 - Responsible for laboratory and course development, including: Water Resources Engineering, Environmental Engineering, Engineering Economics, Geotechnical Engineering, Surveying and GIS, Servant Engineering, and Senior Capstone
 - Adviser for research projects related to water resources systems engineering (see research advising experience above)
- VISION HOPE INTERNATIONAL, SANA'A, YEMEN 2012
Water Resources Engineer
- Responsible for the selection and documentation of Water, Sanitation and Health (WASH)-related labor-intensive work projects within a \$4.3M World Food Program intervention in 2 of Yemen's poorest (with high rates of malnutrition and heavily war-affected) governorates: Hajja and Hodeidah. Through interviews with local Yemeni NGOs, government officials, donors, and aid organizations, approximately a dozen civil engineering and WASH-related projects were selected as labor-intensive, economical interventions in Yemen's health and infrastructure with long-term sustainable benefits to Yemen's people
- SUSTAINABLE ENVIRONMENTAL AND ENERGY SOLUTIONS (SEES), AMMAN, JORDAN 2011
Climate Change and Water Specialist
- Co-authored the terms of reference for Jordan's 3rd National Communication to the United Nations Framework Convention on Climate Change (UNFCCC), including the National Self Assessment evaluating the current state of climate change vulnerability and adaptation in Jordan, and a critical assessment of the gaps/constraints in Jordan's institutions, finances and policies. Contracted by the United Nations Development Program (UNDP Jordan)
- MIDDLE EAST UNIVERSITY, AMMAN, JORDAN 2010-2011
Assistant Professor, Faculty of Engineering
- Instructor for 5 courses: Hydraulics/Hydrology, Fluid Mechanics, Engineering Economics, Numerical Methods for Engineers, and Statics

- ARAB CONSULTANTS BUREAU (ACB), AMMAN, JORDAN 2010
Water Systems Engineer
- Oversight of ACB's quality assurance protocols in satisfaction of requirements of nuclear safety. Reviewer of flood analyses and hydrologic assessments
- MWH, AMMAN, JORDAN 2010
Water System Economist
- Responsible for determination of the Economic Rate of Return on numerous alternatives for Millennium Challenge Corporation \$100M investment in expansion and rehabilitation of the Zarqa wastewater system, Jordan
- TUFTS UNIVERSITY, MEDFORD, MASSACHUSETTS 2003-2010
Researcher, Teaching Assistant, Graduate Student
- Fulbright Fellow: Independent doctoral research – robust optimization the water system in Amman, Jordan
 - National Science Foundation Graduate Research Fellow: Independent doctoral research – deterministic optimization of the water system in Beirut, Lebanon
 - Research Assistant: Water allocation optimization model for Beirut
 - Teaching Assistant: Hydraulics (CE-12), River Hydraulics (CE-131), Probability and Statistics (CE-56)
 - Water SHED Fellow: Researched Best Management Practices for Stormwater control
- CH₂M HILL, BOSTON, MASSACHUSETTS 2001-2002
Civil/Environmental Engineer
- Water treatment plant design in Connecticut
 - Wastewater treatment plant odor control design in Maine
 - Sewer rehabilitation in New Jersey
- UNIVERSITY OF MASSACHUSETTS, AMHERST, MASSACHUSETTS 1999-2001
Honors Undergraduate Researcher
- Designed, constructed and tested bench-scale 740 ml dead-end hollow-fiber membrane bioreactor for hydrogenotrophic denitrification of ground water
- MASSACHUSETTS WATER RESOURCES AUTHORITY (MWRA), CHARLESTOWN, MASSACHUSETTS 1999
Civil Engineering Intern
- Establishment of Standard Operating Procedures for covered storage facilities at Blue Hills and Fells

SERVICE TO THE PROFESSION

MIT Climate Co-Lab Fellow
Adaptation Competition, 2016
Energy-Water Nexus Competition, 2015

REVIEWER

- The Geographical Journal (Royal Scientific Society)
- The International Journal of Environmental Engineering (InderScience)
- The Journal of Environmental Engineering Science (LiebertPub)

- The Journal of Water Resources Planning and Management (ASCE)
- Water Resources Research (AGU)

MEMBER

- American Geophysical Union (AGU)
- American Society of Civil Engineers (ASCE)
- International Water Association (IWA)

CERTIFICATIONS AND TRAININGS

Fundamentals of Engineering (FE) Certification, 2000

TRAINING

- New Faculty Institute (George Fox University)
- Total Quality Management (Tau Beta Pi)
- Project Management Training (CH2M Hill)
- Quality Assurance Systems: ISO 9001, 14001, and NQA-1

INTERNATIONAL EXPERIENCE

COUNTRIES OF WORK EXPERIENCE

Indonesia, Jordan, Kenya, Lebanon, Mexico, Nepal, USA, Yemen

LANGUAGES

- Spanish – basic proficiency
- Arabic – elementary proficiency