Urban Water Innovation Network

Sustainability Research Network

Final Report (2015-2022)

National Science Foundation

The Urban Water Innovation Network is a Sustainability Research Network (SRN) funded by the National Science Foundation (NSF) Cooperative Agreement 1444758. The Network was established in August 2015. The Final Report provides a detailed summary of activities, results and accomplishments over the SRN funding cycle (2015 – 2022). The report also provides a detailed list of partners and collaborators as well as a current list of UWIN-related research products including academic publications, conference papers and proceedings, websites, models, and other related products.

EXECUTIVE SUMMARY

The UWIN SRN research, educational, and engagement activities create scientific advancements that facilitate integrated planning and management of urban water systems. These transdisciplinary activities are conducted to: 1) improve a holistic understanding of the urban water cycle; 2) develop technological, policy, institutional, and financial solutions and pathways toward sustainable, resilient, and equitable urban water systems; and 3) provide interdisciplinary research training opportunities for a diverse cohort of graduate and undergraduate students across UWIN institutions.

The SRN activities engaged over 250 academic collaborators including nearly 70 faculty members (2 deans, 28 professors, 15 assistant professors, 7 associate professors, and 2 instructors) from 35 academic institutions with interdisciplinary expertise, as well was 14 research scientists, 83 graduate students, 71 undergraduate students, 15 postdoctoral research associates, six technicians, and three staff scientists. In addition, nine postdoctoral researchers were promoted to faculty positions during the course of this project. Furthermore, over 100 nationally renowned urban water and sustainability stakeholders from various regions across the U.S. have been involved in the SRN research, engagement, and educational activities. The UWIN SRN fosters ongoing collaborations with 84 organizations across the country including 19 federal/state/local government agencies, 13 non-profit organizations, 10 utility partners, three consulting agencies and four commercial/industrial firms.

The UWIN transdisciplinary activities produced 221 published high impact journal publications; 337 conference papers/posters and presentations; 46 PhD dissertations, Master's and undergraduate theses; 9 book chapters; 3 patents; 89 outreach and print materials; 26 software and modeling tools; 4 websites, and a popular urban water webinar series offering 51 webinars (by both UWIN researchers and regional water stakeholders). In addition, the data, models, software, and other products of the network are published using open-source platforms. Two citizen science projects, the Green Infrastructure Rapid Assessment project and the Off the Roof project were completed and results are being disseminated in relevant presentations and publications.

The Network has established strong partnerships with stakeholders in more than 20 cities across the nation to foster transitions to sustainable urban water systems. UWIN partners developed the One Water Cities Rating System that provides data, assessment frameworks, and indicators to help cities build capacities for integrated management of water and related systems in a changing world. The UWIN SRN products are increasingly used by city managers,

practitioners, consulting firms, and researchers to develop holistic region-specific strategies that safeguard our communities against extreme urban heat, water shortages, floods, and water pollution, while supporting economic growth and sustainable land development. A key feature of UWIN products is the capacity to assess combined effects of population, land use, and climate change on long-term sustainability, resiliency, and equitability of social, infrastructural, and ecological water systems. These capacities include novel approaches for characterization of life cycle costs and life cycle assessment of drinking water, wastewater, stormwater, reclaimed water, and fit-for-purpose water systems. For example, a web-tool was developed to enable life cycle assessment of green and gray stormwater infrastructure at city and regional scales. The tool is currently used in several cities to inform resilient and equitable stormwater infrastructure investment decisions.

The UWIN SRN continues to build collaborations across the U.S. and internationally to develop regional solutions for water challenges. For example, the network researchers led a multi-institutional transdisciplinary research effort to evaluate the resiliency of the New York City's stormwater and flood control infrastructure to climate change and sea level rise. In May 2021, the New York City Mayor's Office released the City's first Stormwater Resiliency Plan, which was supported by UWIN research products.

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MAJOR GOALS

The vision of UWIN is to build an enduring research network that generates knowledge, enables innovation, and trains/supports champions of innovation for sustainable and resilient urban water systems. To implement this vision, the mission of the network is to: (i) develop technologic and sociopolitical solutions; (ii) build social capital and trusted regional leadership in six study regions; and (iii) train scientists and policy makers as champions of innovation for urban sustainability. The initial study regions include Mid-Atlantic/Baltimore, Southeast Florida/Miami, Front Range Colorado/Denver, Arizona Sun Corridor/Phoenix, Southern California/Los Angeles, and the Pacific Northwest/Portland.

Research Goals

Specifically, the overarching research goals of the UWIN SRN are to:

1. Understand responses, interactions and feedbacks between urban development patterns and the interconnected natural/socioeconomic processes (climatic, hydrologic, biogeochemical, and ecological) that impact coupled natural-human water systems;
2. Identify technological, socioeconomic, and urban water management solutions that reduce pressures, enhance resilience and maximize co-benefits in other linked systems, and measure their impacts and tradeoffs across temporal and spatial scales;
3. Explore systemic institutional frameworks required for successful transitions toward sustainable urban water systems in metropolitan regions across the U.S; and
4. Develop a national Urban Water Sustainability Blueprint by creating a conceptual framework that defines essential characteristics of sustainable urban water systems across regions, points decision makers toward best management practices, fosters peer learning and cross site comparisons, and enables agile responses to changes in driving forces that influence urban water systems.

Research activities of the network are organized in four integrated thrusts: A, B, C, and D.

Thrust A projects aim to advance fundamental knowledge about the sustainability of urban water systems, by comparing observed trends in the past with alternative future conditions. First, water supply-demand patterns under prevailing and future socioeconomic scenarios are investigated. These land and water use, land cover and socioeconomic scenarios are then used to assess responses and two-way interactions between urban form/development patterns and land-atmospheric processes in urban areas. The relationship between coupled human-natural urban water systems and regional climate, effects on urban heat islands, and the ensuing co-benefits for human health are investigated.

Using data, models, and enhanced process understanding from Thrust A, the impacts of innovative technological solutions on sustainability of water systems across ecohydrologic regions are examined under Thrust B. These solutions include: building- to community-scale resource recovery and reuse systems, hybrid centralized-decentralized water infrastructure systems, fit-for-purpose water systems, green infrastructure, sustainable urban drainage networks (SUDS), and resilient floodplains.

Activities under Thrust C explore how cities can intentionally foster the widespread adoption of infrastructure, development patterns, consumer behaviors, and management practices that advance sustainable water management. To understand overcoming barriers to adoption of sustainable

solutions, the social and behavioral systems that govern change are investigated. Components of the system include the actors, preferences, policies, institutions and other elements that shape outcomes at multiple scales from the site to the metropolis. Theories of urban change are studied to understand the social networks that shape water systems, the dynamics of household innovation, and the processes of large-scale urban change.

Thrust D activities focus on integration of data, models and products from all other themes and projects to facilitate enhanced decision making. This thrust enables synthesizing results from assessment projects under Thrust A, technological solutions under Thrust B, and socioeconomic and management solutions under Thrust C to identify viable options that provide maximum benefits at the system level. A system approach following an urban water sustainability framework is used to explore driving forces, pressures, states, impacts, and responses/solutions. This system approach explores benefits, dis-benefits, co-benefits, and tradeoffs associated with various solutions at various spatial and temporal scales. The synthesis will determine the sustainability metrics/indicators that comprise UWIN Urban Water Sustainability Blueprint.

Outreach/Stakeholder Engagement Goals

The overall goals of the stakeholder engagement components of the project are to: (i) gather feedback and input from stakeholders to ensure that UWIN science is as relevant as possible to decisions and drivers of regional concerns; (ii) compare findings from observations and analyses of stakeholder interactions across regions; (iii) use stakeholder engagement activities to serve as testbeds for tools and products developed through the project; (iv) measure the change in network composition and extent.

The overall goals of the training component are to: (i) provide adaptive management/team science skills training to UWIN researchers so that participants will become increasingly adept at working with complex transdisciplinary project teams; and (ii) provide training on skills and tools that support fostering effective communication, building cohesion, coordinating work, appreciating dependencies, aligning team members, and integrating knowledge.

Education Goals

The goals of UWIN Undergraduate Research Program (URP) are to: (i) provide a diverse group of undergraduate students mentored independent research experiences in urban water sustainability, immersing them in the challenges and rewards of transdisciplinary scholarship and helping them in their career choices and success; (ii) develop and test innovative approaches to undergraduate training in transdisciplinary, cross-site sustainability science, while also contributing to the scholarship of undergraduate education; and (iii) contribute to the UWIN research and engagement.

Specifically, student-oriented goals of the URP are to: develop strong research and inquiry skills; gain deeper knowledge in the field of urban water systems sustainability; develop skills for inter- and transdisciplinary work; understand key linkages between science and society; acquire skills in connecting scientific research to policy/management, communication, and education. The URP also contributes to personal and professional development of students to become more confident in the ability to do independent research, experience the enjoyment of working with transdisciplinary research, learn how to effectively interact with colleagues, advisors, mentors, and people outside their discipline, build positive relationships and networks to support future career development, and become reflective practitioners of scientific research and transdisciplinary science.

Mentor-oriented goals of the UWIN URP are to understand best practices to engage students in transdisciplinary research involving scientists, policymakers, and stakeholders; expand and evaluate students' thinking and understanding of science and its application to sustainable urban water systems; act as professional role models to students; and develop strong mentoring skills.

Programmatic goals of UWIN URP are to engage a diverse group of students, including race, background, type of school, career interest, and perspective; generate new knowledge and solutions for urban water sustainability that impact a broader audience; forge collaborations among researchers, regional stakeholders, students, and the global community; provide innovative and effective training for a new generation of transdisciplinary researchers prepared for the new challenges and opportunities they will encounter; and contribute to understanding of the roles that research experience and reflection play in undergraduate learning and vocational development.

Citizen Science Goals

The Network is engaged in several Citizen Science efforts, including a program on harvested rain waiter and a green infrastructure monitoring program. The major goals of the Citizen Science efforts are to:

- Contribute to UWIN science, products and participant pool
- Convene interested members of the UWIN community to explore citizen science initiatives for UWIN, and to support ongoing and new citizen science activities through exchange of ideas and resources
- Identify win-win opportunities where UWIN and other scientists, community stakeholders and members of the public can all benefit from citizen science projects

Diversity Goals

The UWIN SRN is fully committed to building a talented and diverse student cohort. The diversity activities are focused on broadening participation in urban water sustainability research through recruiting and retaining underrepresented groups through the creation of Diversity Recruitment and Retention supplements. UWIN Diversity Supplements are intended to complement existing activities and programs already in place at the Network's affiliated institutions.

- Research
    - Recruit diverse faculty, post docs, and graduate students, as applicable, to participate in UWIN research projects
    - Conduct workshops and seminars that promote a welcoming environment for diverse researchers
    - Establish a partnering program that pairs new participants with mentors/guides who have experience working with UWIN staff and projects to promote meaningful engagement in project activities
    - Identify diverse researchers to participate in dissemination activities as keynote speakers, featured presenters, etc.
    - Make presentations to minority and women engineering societies to promote awareness of the research topics amongst the traditionally underrepresented minority community
- Education & Outreach
    - Recruit diverse student participants in education programs (include participation in conferences like NSBE, SWE, SHPE, SACNAS, AISES)

    - Secure the participation of diverse researchers to be education program facilitators and provide mentoring to student participants, especially underrepresented students
    - Promote a supportive, welcoming environment for diverse participants
    - Plan community awareness events, especially, in diverse communities affected by issues related to the work of UWIN, that highlight research projects and results and promote citizen participation
    - Develop a diverse public image through the project website and other forms of media
- Engagement
    - Engage a diverse group of advisors on the overall project advisory board and regional advisory boards

MAJOR ACTIVITIES

The SRN activities were conducted in 22 research projects, a stakeholder engagement project, an Undergraduate Research Program (URP), and training opportunities for graduate and undergraduate students.

"Thrust A" Research Projects

A1-1: Quantifying vulnerability, resiliency and adaptability of US urban water supply

- Integrated water supply, water demand, and water allocation data and models for all river basins in the Conterminous U.S. to simulated water delivery to municipal and agricultural sectors over a range of climate and population change scenarios.
- Characterized water use trends and patterns for approximately 150 cities in the U.S.
- Assessed the vulnerability of water supply systems in the U.S. to shortage over a range of climate and population change scenarios.

A2-1: Land-atmosphere-hydrosphere interactions in urban terrain

- Applied the newly developed WRF(LES)-PUCM-ParFlow model to a small test watershed in Baltimore to investigate the effect of highly-resolved urban hydrometeorological processes and three-dimensional groundwater flow on output variables such as overland flow, soil moisture, and surface temperature.
- Analyzed temperature data in urban stream to identify the drivers of temperature surges in streams. We then showed that the urban streams with frequent and intense surges also tend to have higher baseline temperatures.
- Re-examined the relation between momentum and scalars roughness lengths in urban areas using building resolving large-eddy simulations.

A2-2: Projecting future environmental change in urban areas

- Initiated and completed continental U.S. climate data upload and publication under FAIR guidelines via collaboration with ASU Libraries.
- Continued broad dissemination of results and products.

A2-3: Assessing the thermal comfort implications of water-supported infrastructure

- Conducted interviews with urban forestry program managers across U.S. cities as part of a collaboration with a CNH2 project led by Darrel Jenerette (URP project, two mentored students).

A2-4: Assessment and design of innovative building systems and urban infrastructure

- Carried out systematic analysis of globe thermometer for measuring radian heat transfer from surfaces and influences of air movement.
- Added a shortwave component to our longwave radiant heat transfer sensor to improve discretization of spatial variation in both visible and thermal wavelengths for urban heat, and planned deployment.
- Constructed downdraft evaporative cooling prototype for outdoor cooling in hot arid climates.

A3-1: Variation in urban vegetation biodiversity-ecosystem functioning

- Conducted cross site comparisons of urban vegetation – microclimate distributions.
- Constructed a new urban tree drought stress experimental testbed.
- Evaluated urban plant biodiversity distributions.

"Thrust B" Research Projects

B1-1a: Water management solutions to enhance capacity for use of alternative water sources

- Conducted a holistic assessment of benefits and consequences for municipal water demand reduction and fit-for-purpose water systems.
- Collected data on microbial quality of stormwater to inform treatment required for fit-for-purpose use.

B1-2: Lifecycle assessment of urban water systems

- Completed a life-cycle assessment study of the energy demand and greenhouse gas emissions associated with water demand reduction strategies and tradeoffs in Tucson, Denver, and Miami.
- Completed a life-cycle assessment study on the correlation between urban densification and water savings.

B2-1: Effects of green infrastructure (GI) on urban systems

- Analyzed data and modeling results to understand the role of green infrastructure in governing storm event response quantity and quality in Tucson, AZ, and other UWIN regions.
- Worked on deployment of flood monitoring equipment.

B2-2a: Flood hydrology and rainfall frequency

- Developed and implemented storm catalogs and rainfall frequency analysis procedures using Stochastic Storm Transposition for heterogeneous urban environments.
- Implemented new polarimetric rainfall algorithm for extreme rainfall events in urban environments.
- Analyzed extreme rainfall and flooding in the Baltimore, Houston and Kansas City metropolitan regions.

B2-2b: Hydrology and hydraulics of urban floodplains

- Analyzed new flood risk data (including future flood risk projections under climate change) for Athens-Clarke County, GA.
- Developed spatial analysis methods to analyze the flood risk data and conducted social vulnerability analyses to assess relative exposure of different populations.
- Created digital elevation models (DEMs) from SfM remote sensing data used in HEC-RAS modeling to understand the importance of high resolution DEMs on 2D hydraulic modeling outcomes and to assess the effects of restoration and alteration of the channel-floodplain relationship on propagation of the flood wave and flow patterns along the valley.
- Analyzed changing probabilities of intense precipitation and frequency of flow peaks over threshold in urban watersheds using 21 years of high-resolution radar rainfall and comparison of time trends with streamflow records are in progress and expected to yield a manuscript for publication this summer.

B3-1: Flood risk to assets and socioeconomic sectors in a changing world

- Developed a risk analysis framework for characterization of risks from compound storm surge and riverine flooding in coastal regions across the U.S.
- Assessed changes in the frequency of compound storm surge-riverine flooding over a range of climate change scenarios in coastal regions across the U.S.

B4-1: Greywater Reuse: Pathogen Removal by a Membrane Bioreactor

- Designed and developed operational parameters for an integrated membrane bioreactor setup, which were developed based on Suez Lab-scale ZeeWeed 500 membranes.
- Collected and tested greywater samples for turbidity, pH, conductivity, and organic matter content with model bacteria and virus strains selected for spiking greywater samples.

"Thrust C" Research Projects

C1-1: Understanding adoption of sustainable urban water solutions

- Analyzed and processed survey data and constructed derivative datasets for analysis.

C2-1: Homeowner adoption of sustainable urban water solutions

- Completed data collection and continued analysis of the data.

C3-1: Transitioning to socially equitable and environmentally just sustainable urban water systems

- Completed additional follow-on analyses information about household water expenditures, social vulnerability to floods hazards, and health consequences of unaffordable water bills in low-income households and completed analysis of equitable urban adaptation to extreme heat.
- Prepared the Survey of Water Indicators and Socioeconomic Status of Households (SWISSH) for publication, a C3-1 survey conducted in nine UWIN study regions (n = 9,250).

C4-1: Financial models and strategies to support the transition to One Water

- Completed and published work on customer willingness to pay for water supply project attributes
- Conducted research to evaluate property losses associated with contaminated water (chemical spills).

"Thrust D" Research Projects

D1-1: Modeling present and future values for sustainable water management blueprint indicators

- Completed model runs, and prepared and submitted publications from (1) modeling alternative future scenarios at watershed scale with UWINvision, and (2) from modeling these same alternative future scenarios at the neighborhood scale with SWMM-5.
- With assistance from doctoral student Michael Tchintcharauli-Harrison, mentored REU student in use of MODFLOW to investigate impact of drywells on groundwater flow in Portland. This doctoral student also continued dissertation research studying sources of water to Crystal Springs in Portland, OR, and impact of drywells on groundwater.
- Collaborated with OSU Computer Science class to develop a "serious game" app that helps teach the public about the value of bioswales as green infrastructure.

D1-2: Cross-site comparisons and contrasts across eco-hydrological regions

- Assessed the carbon sequestrations, air quality, energy savings, UV exposure, and other cobenefits of green stormwater infrastructure systems in Philadelphia.
- Compiled a dataset of green infrastructure systems across U.S.
- Assessed the effects of grey and green stormwater infrastructure in the New York City on flooding and combined sewer overflows over a range of climate change and sea level rise scenarios.
- Assessed cost, reliability, and resiliency tradeoffs of municipal water demand reduction strategies across UWIN cities.

D1-3: Urban water decision innovation system

- Developed and tested the CLASIC tools for lifecycle cost assessment tool to support stormwater infrastructure decisions on extent and combinations of green, hybrid green-gray and gray infrastructure practices.
- Developed the POLARIS tools in collaboration with several utility partners to foster integrated land use and water planning in cities.
- Developed a municipal water demand modeling tool to enable assessment of water demand reduction, fit-for-purpose use, climate change, land use change, and population change scenarios.

Stakeholder Engagement

- Conducted a series of stakeholder engagement workshops to better understand regional drivers, pressures, challenges, and research needs.
- Designed interview protocol and survey instruments to inform UWIN One Water framework and progress rating system; conducted 15 expert informant interviews with global stakeholders.
- Analyzed the transdisciplinarity of the UWIN SRN through survey and publication network analysis.
- Investigated marketing strategies for integrated urban water management.

Undergraduate Research Program (URP)

- Recruited 48 students from a pool of 1624 applicants participated in the 9-week UWIN URP during the summer of 2016-2020, working with 16 mentors.
- The applicant pool was 23% underrepresented minorities (URM), 60% female and included students from a wide range of majors and institution types.
- Organized the rich and diverse datasets from the 5 years of URP in preparation for analysis.

SPECIFIC OBJECTIVES

The objectives of the UWIN SRN are presented for the 22 research, stakeholder engagement, and Undergraduate Research Program (URP) efforts.

"Thrust A" Research Projects

A1-1: Quantifying vulnerability, resiliency and adaptability of US urban water supply

- Develop and quantify water supply sustainability indicators
- Assess the effects of water management solutions under current and alternative future conditions

A1-2: Effects of changes in climate, demographics and urban form on water supply-demand equilibrium

- Create a database of past, present, and future household water use and prices
- Generate projections of future water demand
- Analyze past and present water prices to generate estimates of future water prices
- Assess the economic impacts of water price on regional economies
- Produce information about the economic impacts associated with regulation strategies

A2-1: Land-atmosphere-hydrosphere interactions in urban terrain

- Couple the WRF and UCM models
- Develop an enhanced representation of trees and surface-air exchanges in the WRF-UCM
- Assess the influence of urban expansion and evaporative cooling infrastructure on the urban environment

A2-2: Projecting future environmental change in urban areas

- Quantify the dynamically interactive effect of increased emissions of greenhouse gases (GHGs) and anthropogenic landscape change associated with urban expansion for the CONUS
- Examine the efficacy of locally deployed urban adaptation and mitigation solutions

A2-3: Assessing the thermal comfort implications of water-supported infrastructure

- Understand health sector perspectives on relationships between urban water systems, climate change, thermal comfort, and heat illness
- Construct a set of detailed time and activity diaries for representative urban dwellers
- Measure the microclimatic conditions experienced by urban residents
- Model how changes to water-supported urban infrastructure as well as urban climate may impact individually experienced thermal comfort for urban dwellers

A2-4: Assessment and design of innovative building systems and urban infrastructure

- Quantify localized impacts on temperature and humidity from building system interactions
- Improve characterization of building energy equipment relationships to climate and water use
- Create a method to deploy thermal cameras to measure the impact of radiation from thermal surface profiles on the heat index
- Create an improved heat index for thermal stress that better incorporates humidity, convection and radiation with the temperature

A3-1: Variation in urban vegetation biodiversity-ecosystem functioning

- Assess vegetation biodiversity distributions and vegetation density distributions throughout each UWIN region
- Evaluate effects of vegetation biodiversity and density on local cooling
- Identify trajectories of changing vegetation biodiversity, density, and ecosystem amenity trade-offs
- Conduct targeted studies of GI to evaluate importance of vegetation distributions to production of ecosystem services and associated water demands

"Thrust B" Research Projects

B1-1: Water management solutions to enhance capacity for use of alternative water sources

- Assess the effects of urban development patterns on water demand
- Assess co-benefits of alternative water management solutions, including reduction of energy demand and GHG emissions
- Assess the effects of alternative water sources, fit-for-purpose water, and conservation strategies on vulnerability, reliability and resilience of water supply systems

B1-2: Life-cycle assessment of urban water systems

- Create decision-support tools for evaluating non-traditional water sources under current and future conditions using life-cycle assessment (LCA) with regionally-appropriate data
- Characterize existing centralized gray urban water infrastructure in case-study cities to provide a baseline for comparing alternative technologies
- Connect ReNUWIt ERC and UWIN researchers doing similar research to maximize synergies

B2-1: Effects of green infrastructure on urban systems

- Understand the effects of Green Infrastructure (GI) on hazard mitigation in humid versus arid climates (efforts in arid regions focus on stormwater use while in humid regions the focus is on minimizing runoff and increasing water quality treatment)
- Assess co-benefits of GI, with a focus on heat island, shade and the support of natural and landscape vegetation in arid regions, while in humid regions focus is on aesthetic

B2-2a: Flood hydrology and rainfall frequency

- Demonstrate a predictive understanding of urban flood hydrology
- Characterize the climatology of flood-producing storm systems
- Develop and implement procedures for rainfall and flood frequency analysis

B2-2b: Hydrology and hydraulics of urban floodplains

- Create urban floodplains under uncertainty in the six study regions
- Compare and contrast the flood resiliency benefits of GI, Low Impact Development, and Sustainable Urban Drainage Systems
- Provide floodplain mapping scenarios for increased resilience to extreme events
- Provide an expanded palette for design of floodplain-greenspace networks that also increase biodiversity, moderate temperatures, cleanse air, and enhance health and happiness

B3-1: Flood risk to assets and socioeconomic sectors in a changing world

- Characterize observed and future changes in flood frequency for cities across the U.S.
- Develop a framework for assessing flood risks to assets and communities
- Assess effects of interventions and responses on the vulnerability of communities to coastal, riverine, and compound flooding

B4-1: Greywater Reuse: Pathogen Removal by a Membrane Bioreactor

- Determine the operational parameters and evaluate pathogen removal efficiency of a small membrane bioreactor (MBR) designed to treat grey water for reuse as irrigation water for urban gardens.
- Investigate the performance of a submerged MBR for pathogen removal as well as the operational parameters affecting the removal

"Thrust C" Research Projects

C1-1: Understanding adoption of sustainable urban water solutions

- Understand the nature and drivers of sustainable urban water policy learning
- Characterize the fragmentation of water governance

C2-1: Homeowner adoption of sustainable urban water solutions

- Understand how adoption decisions for sustainable urban water solutions are made
- Understand individuals' willingness to make large investments in long-term solutions and the different factors that influence willingness to pay across the selected study sites
- Understand how to empower individuals and communities to take a long-sighted view and how to encourage long-term planning and investment

C3-1: Transitioning to socially equitable and environmentally just sustainable urban water systems

- Understand inequalities in existing urban water systems
- Investigate which people and places bear more burdens and receive more benefits from current water systems and practices
- Explore expected or observed impacts and co-benefits of sustainable water solutions (i.e., One Water pathways) on underrepresented groups

C4-1: Financial models and strategies to support the transition to One Water

- Explore governance, financial strategy, economic viability, and public support perspectives of One Water
- Outline the current financial models for separate water services and the extent of their integration
- Identify instances where the current water management model works well and challenges it poses to the One Water model

"Thrust D" Research Projects

D1-1: Modeling present and future values for sustainable water management blueprint indicators

- Develop a consistent representation of the landscape change drivers, processes, and metrics for urban water system sustainability
- Develop U-envision, an alternative futures modeling framework to model future scenarios for urban water systems and to evaluate a suite of sustainability-oriented indicators
- Pilot the use of U-envision, in the Willamette Valley in Oregon

D1-2: Cross-site comparisons and contrasts across eco-hydrological regions

- Synthesize city water data and information from other projects
- Identify optimal water management solutions under deep uncertainty
- Explore tradeoffs associated with water solutions for current and alternative future scenarios
- Identify water management solutions that are most consistent with stakeholders' preferences

D1-3: Urban water decision innovation system

- Develop the Water Connect App for engaging the urban water community to contribute to the development of the UWIN Urban Water Sustainability Blueprint
- Develop web-services for characterizing urban water sustainability indicators
- Develop a multi-criteria decision analysis tool to assess social, economic, and environmental tradeoffs in meeting desired water management targets

Stakeholders & Training

- Elicit active stakeholder contribution to research and outreach
- Build social capital through network development
- Build inter-regional horizontal connections and capacity for information exchange
- Create “safe spaces” for innovation
- Elicit feedback to develop the Urban Water Sustainability Blueprint

Undergraduate Research Program (URP)

- Explore interdisciplinary questions
- Accelerate student learning and development of identity and confidence as scholars
- Promote diversity in the SRN

RESULTS

"Thrust A" Research Projects

The performance of WRF-urban deteriorates significantly at finer resolutions. This underscores the need for coupling the classic tools of urban climate modeling to subsurface hydrological models, and for improving the initialization of soil moisture. The resulting spatiotemporal variability of urban heat islands (UHIs) can be very significant within a city, altering wind patterns and the efficacy of adaptation and mitigation measures, and creating a hydrological UHI that manifests as higher temperature for urban surface water bodies. To mitigate these heat risks, we applied a needs-based targeted implementation of cool roofs in the most heat-sensitive, low-income areas of Maricopa County, Arizona, and found that they promote equitable heat adaptation and reduce heat exposure for the largest absolute number of people.

In addition, we showed significant potential utilization of energy in wastewater streams, built new surface temperature scanning devices, and measured surface temperatures showing considerable spatial variation in urban heat impacts with relationship to green and blue infrastructure surfaces. We generated a well-calibrated approach for assessing outdoor water use to evaluate changes in response to restrictions and showed that vegetation increase leads to reduced nighttime air temperature and daytime land surface temperatures. We developed high resolution water and wastewater costs databases that facilitate unique analyses of water affordability at a high spatial resolution. The household survey data provide one-of-a-kind information about households experiences with water.

The end-of-century summertime urban warming resulting from the interactive combination of urban expansion and increased concentration of GHGs can reach up to 6C in the afternoon and up to 8C during evening and nighttime hours across CONUS cities, for the most impacted cities and critical pathways, compared to the first decade of the current century. Locally deployed urban adaptation strategies have their greatest effect on reducing daytime temperatures, with minimal impact during evening or nighttime hours. The combined impact of urban expansion and increased concentration of GHGs broadly enhances extreme precipitation across CONUS metro-areas.

"Thrust B" Research Projects

Stormwater capture and use systems offer multiple benefits for water demand reduction, flood control and achieving sustainability indicators. Specifically, green stormwater infrastructure combined with roof runoff harvesting can meet most of the irrigation demand for both single family residences and street trees in at least one semi-arid city. However, these systems come at a high cost and stormwater requires a high level of treatment to remove pathogens to ensure public health. Innovations in treatment are needed to reduce costs and energy required and membrane bioreactors show promise for pathogen reduction.

Complementary benefits on flood and combined sewer overflow reduction can be gained through integration of green and gray infrastructure systems. These benefits can also be achieved by integration of distributed green infrastructure with stormwater capture and use.

Green infrastructure (GI) was shown to have little effect on flood hazards and overall volumes under current levels of implementation, but higher levels of implementation may have some effect on flood flows, particularly the shorter return period storms. Therefore, GI would be more effective at minimizing frequent floods while less frequent, more harmful floods would be more of a challenge.

Rainfall frequency analyses using long-term, high resolution radar rainfall fields and "Stochastic Storm Transposition" provide major advances in characterizing flood hazards in urban watersheds. These techniques are especially important for assessing short-duration (sub-daily) rainfall extremes over urban watersheds. For many urban settings in the US, extreme convective storms are important agents of extreme rainfall for time scales shorter than 24-hours; polarimetric radar methods are particularly useful for these storms.

Changing precipitation, land use, and river channels introduce uncertainty into flood predictions and pose challenges for floodplain management and mitigation. Standard methods for quantifying flood hazards and evaluating risk assume stationarity in a nonstationary world and fail to account for uncertainties as they translate to flood hazards. Novel methods for probabilistic floodplain mapping under nonstationarity revealed areas of elevated or hidden risk across humid, semi-arid and arid UWIN study regions that were not revealed by deterministic regulatory flood hazard boundaries. Further, the approach indicates a significant increase in flood hazards associated with climate change and suggests that regulatory floodplain boundaries underestimate and miscommunicate risk status.

We used long term hydrologic modeling of 10 precipitation regions in the contiguous US to assess the effects of bioretention size, soil infiltration rate, storm size, and climate on the watershed-scale performance of green stormwater infrastructure (GSI). Bioretention areas did provide watershed-scale benefits, although performance declined as 1) bioretention areas became smaller, 2) soil infiltration rates decreased, and 3) precipitation depth increased. High intensity rainfall was the primary cause of outflow from bioretention areas, although frequent back-to-back events also caused outflow in some climates. There were some clear discrepancies between sub-basin scale and watershed-scale performance of GSI. Generally, runoff volume reduction was greater when measured at the sub-basin scale. Peak flow reduction, however, was greater at the watershed-scale, primarily because bioretention cells altered the shape of the runoff hydrograph, leading to greater cumulative peak flow reductions than were seen in individual sub-basins. Bioretention soil infiltration rates have much less of an effect on performance than bioretention size, storm size, or rainfall patterns.

We also used continuous hydrologic model simulations of watershed-scale response to stormwater control measures (SCM) design scenarios with channel evolution modeling to examine interactions between stormwater management and stream restoration strategies for reducing loading of sediment and adsorbed phosphorus from channel erosion. Modeling results indicate that integrated design of SCMs and stream restoration interventions can result in synergistic reductions in pollutant loading. Not only do piecemeal and disunited approaches to stormwater management and stream restoration miss these synergistic benefits, they also make restoration projects more prone to failure, wasting valuable resources for pollutant reduction.

The novel proposed mixture probability model allows to simultaneously investigate minor and extreme coastal flooding frequency under future sea level conditions. Under future sea level rise scenarios, while regions in the Pacific and southeast Atlantic coast are likely to be exposed to higher frequency amplification in extreme flooding, the Gulf and northeast Atlantic coastal regions should expect the highest minor flood frequency amplification. Also, we show that as sea level rises, chronic risks from repetitive non-extreme flooding will exceed acute risk from extreme floods in Miami-Dade County.

"Thrust C" Research Projects

A meta-analysis of research shows convergence of theoretical and empirical literatures on policy change. Statistical models show that use and consideration of sustainability practices are linked to local policy networks. Governments with larger networks tend to implement higher numbers of sustainable water practices. Non-governmental organizations, especially water sector organizations, are key drivers of the use of sustainable practices. Governments with a higher number of connections to non-governmental organizations are more likely to use a broader array of practices and governmental organizations are more likely to consider novel water sustainability practices that are used by non-governmental organizations with whom they are connected.

Significant links exist between innovation networks and routine water management activities. Organizations who are more central in networks tend to take advantage of this position and establish more collaborative and voluntary interventions. However, this effect is absent in coalition networks, networks of organizations with similar agendas. Innovations in water management take the form of experimentation across governmental and non-governmental stakeholders, context-sensitive selection, and incremental change.

On the homeowner scale, results show a shift towards higher likelihood of adoption of greywater systems on the 5- to 10-year timescales in comparison to more immediate timescales. Of those willing to adopt, more than 80% see a government incentive/rebate program as moderately to extremely important to the decision to adopt. Another factor influencing greywater adoption decisions across study sites is market saturation. Results show that 60% of respondents across study sites would be more likely to adopt a greywater system if some or most of their neighbors have positive experiences with greywater systems, bringing into the mix the "neighbor effect" on technological adoption and diffusion. Most responders report willingness to pay less than $500 for the installation of a greywater system, with the second highest group capping investment at $1000.

In terms of public perceptions, the U.S. public perceives substantial risks to their households from water-related hazards. In SWISSH, the rising cost of water had the highest mean risk perception score, followed by polluted waterways, and contaminated drinking water. Twelve to fifteen percent of U.S. households have unaffordable water bills according to the US Environmental Protection Agency definition. Water service providers threatened 5% of the SWISSH sample with water shutoff notices, and they shut off water to 3% of the sample households in 2019. People who struggled to pay water bills experienced housing and food insecurity, underutilized health care and medication, and suffered severe mental stress. Racial inequalities in unaffordable household water bills and water shutoffs are a national problem. Every 10-percentage point increase in the community share of minorities (Hispanic, Black, and Native population living in a Zip Code Area) was associated with 6% higher odds of households in that community having unaffordable water bills. Leaders of community groups and nonprofits believe that racial discrimination, the commodification of water, and environmental regulatory failure are the three main barriers to water sustainability in their environmental justice communities.

The results identified the complementarity of energy and water use in the household. Simply put, increases in energy price result in small, but significant decreases in water use for residential households. This result provides evidence that energy and water utilities should have jointly determined utility rates to ensure effective policy. Additionally, we assessed the sensitivity in water use estimation to specific weather variables. Understanding how to accurately predict daily, monthly, and annual water use will allow utilities to make more efficient decisions in treatment and water portfolio acquisitions.

We find compelling evidence that for residential homes, precipitation and temperature averages provide sufficient information to accurately predict demand. Thus, parsimonious models may be preferred to more complicated models that include windspeed, evapotranspiration, and other secondary weather indicators.

We also used case studies to identify successful techniques in funding One Water approaches. While there is no brightline method for successful integrated management, utilities with proven track records use a variety of options. Of the thirty-six examples studies, successful strategies involve organizational approaches, regional shared governance, partnerships, resource conservation, corporate social responsibility, though specific financial innovation was rare.

We also examined the non-market costs of chemical contamination and found substantial changes in home values (decreases around 10%) following such spills. Currently, municipal water utilities have limited ability to receive compensation for these accidents, since companies responsible can declare bankruptcy to avoid liability.

Lastly, we conducted a survey and discrete choice experiment to identify water customers preference for and willingness to pay for co-benefits associated with increased water supplies. In general, we find extremely strong support for including co-benefits in water infrastructure investments.

"Thrust D" Research Projects

Green stormwater infrastructure (GSI) systems improve the hydrologic response of urban systems by decreasing impervious surfaces and increasing infiltration. The reduction of runoff from impervious surfaces from implementation of GSIs varies by precipitation regimes and physiographic characteristics of where they are implemented. Highest effects from GSIs are realized in areas with high levels of impervious surfaces. Once the design storage capacity of GSIs is exceeded, their effects on stormwater and flood control as well as water quality improvements diminish. GSIs also provide significant co-benefits for air quality improvements, greenhouse gas (GHG) emission reduction, UV exposure reductions, and energy savings. These co-benefits vary by ecohydrologic regions and characteristics of trees that are used in GSIs.

Policy choices and management actions that anticipate and plan for the impacts of climate change and population growth can help decrease the effects of climate change and urbanization while improving the sustainability of urban systems.

Wildfire, forest harvest and development have similar effects on the watershed hydrologic response by decreasing evapotranspiration, and increasing runoff and streamflow, but through very different mechanisms.

Results from neighborhood, watershed, and basin-scale modeling highlight the importance of considering impacts across scales. In the western U.S., climate change dominates impacts at the basin scale through loss of snow, increased uncertainty for water storage, and increased wildfire. Different regions respond differently to the changes predicted for both climate and development. These geographic differences form the backdrop for variable responses across basins and at the watershed scale. Impacts from development dominate the response of the urban water system at the neighborhood scale, however, regional impacts of climate change (e.g., heat, wildfire, air quality, flooding) also impact urban neighborhoods.

Stakeholders & Training

Key findings of stakeholder engagement are that (1) stakeholders consider climate change impacts, water quality impairment, and aging infrastructure to be their greatest challenges to sustainability, and (2) innovative solutions that could address limited public awareness and support for water management efforts and enhanced communication with decision makers were most desired across the project's diverse regions.

A survey of all project participants indicated that the Network grew substantially over the course of the project. While there were approximately 700 links of familiarity between individuals on the project at the outset, there were 2,700 after 2019. The UWIN network grew substantially during the project in the number of individuals engaged, their connectivity, and their participation in interdisciplinary work.

In a follow-up survey, 74% of the 2016 training cohort graduate students reported that the workshop influenced their thinking somewhat to very much and 63% used one or more of the skills/techniques. Visualize/brainstorming was the most commonly used technique (52%).

Undergraduate Research Program (URP)

Undergraduates are interested in transdisciplinary research, Network Science and urban water sustainability: There was abundant evidence that the essence of UWIN - One Water and transdisciplinary (TD) approaches to urban water sustainability – were extremely engaging to students. From the very large number of highly diverse and qualified applicants to the very high ratings students gave to these facets of the program in post-program and alumni survey, it is clear that students are thirsty for opportunities in this arena. The persistence of many of the students in related fields provides additional support for this assertion.

Undergraduates are capable of applying TD and teamwork approaches to urban water sustainability challenges and made significant gains in these areas through the URP: Students showed significant gains in the TD disposition and sustainability competency scales measured in pre- and post-program surveys. Training in teamwork and explicit attention to the mentor/mentee relationship built students' skills for self-reflection and effectiveness as collaborators and mentees. Students' reflective writing and Case Study product give evidence to sophisticated appreciation of the rich complexity of TD approaches.

Student participants make significant gains in all areas targeted for student growth, supporting our hypothesis that a suite of outcomes can be achieved: Self-reported gains in confidence for research, vocational, TD and social skills tended to be greatest for students with the lowest pre-program scores, suggesting that the program could be effective at bringing all students to a similarly high level of competence. There were no significant differences in gains between students with different majors, nor for students from different backgrounds, providing additional support to this finding.

An authentic Case Study can foster a great deal of learning and accomplishment: The Case Study developed during the URP was a highly effective way of engaging a very diverse group of students in a real-world exploration of urban water sustainability challenges. Rather than lecturing to them about this topic, students met stakeholders who helped them both understand the complex water system in the Front Range and appreciate the diversity of perspectives, knowledge and values different people bring to the challenge. The Case Study occupied the equivalent of two of the three days of the kickoff meetings, approximately six hours of seminars and discussion during the 8-week research period, and another four hours at the wrap-up meeting, for a total of roughly 26 hours of their summer. The outstanding products that emerged from the Case Study each year, the very high ratings it received from

students in post-program surveys and focus group discussions, and the impressive gains made in the areas touched upon by the study all support the conclusion that this can be a very effective and efficient way of achieving diverse and important outcomes.

Mentors and non-mentor members of the network benefit: There was an extremely high level of enthusiasm for the URP among mentors and other members of the UWIN community. While thrilled with URP students' contribution to 13 peer reviewed publications (plus 2 in preparation), the high esteem of the program hinged mainly on the high level of satisfaction with interactions with the students and a sense of pride in the innovative nature of the program and its contribution to the field.

KEY OUTCOMES

Research

The SRN activities engaged over 250 academic collaborators including nearly 70 faculty members (2 deans, 28 professors, 15 assistant professors, 7 associate professors, and 2 instructors) from 35 academic institutions with interdisciplinary expertise, as well was 14 research scientists, 83 graduate students, 71 undergraduate students, 15 postdoctoral research associates, six technicians and three staff scientists. In addition, at least nine postdoctoral researchers were promoted to faculty positions during the course of this project. Moreover, over 100 nationally renowned urban water and sustainability stakeholders from various regions across the U.S. have been involved in the SRN research, engagement, and educational activities. The UWIN SRN fosters ongoing collaborations with 84 organizations across the country including 19 federal/state/local government agencies, 13 non-profit organizations, 10 utility partners, three consulting agencies and four commercial/industrial firms.

The UWIN SRN activities has created, for the first time, an integrative assessment framework that underpins development of strategies for integrated planning and management of urban water systems, enable incorporation of decentralized regenerative technologies and infrastructure systems that enhance the resilience of water systems in cities, and enhance the co-benefits of urban water systems for improved air quality, biodiversity, readiness to climate change and extreme events, and community livability. A cyberinfrastructure is developed and piloted in several cities in the U.S. and internationally to enable communities identify solutions that best meet their need to address regional water challenges in a variety of contexts from coastal communities to high plain desserts.

The SRN transdisciplinary activities to date have produced:

- 221 high impact journal publications
- 337 conference papers, posters and presentations
- 46 PhD dissertations and M.S. theses
- 9 book chapters
- 3 patents
- 89 outreach and print materials
- 26 software and modeling tools
- 4 websites
- 51 webinars
- 40 datasets

Integration Efforts

Several integrative projects were identified by project leadership to help cities transform urban water management systems through integrated approaches. UWIN established Task Forces to outline plans for the creation and development of the products listed below:

- **Sustainability Indicators**: Urban Water Sustainability Indicators are developed to provide a roadmap and compass for our collective research efforts, thus contributing to a concrete and internally consistent set of indicators is a key integrative activity within UWIN.
- **Testbed studies**: These studies are conducted to investigate technological, policy, institutional, and financial pathways that foster integrated planning and management of urban water systems, and advance transitions toward a “resource management” model, which aims to maintain or restore the natural and social capital of cities, including: reliability of water supply, water quality control, and flood control services; resilience to changes in climate, population,

land use, and economic conditions; biodiversity (functional diversity); social environmental justice and equity, and community health and livability.

- **Synthesis papers**: Several cross-cutting academic publications are produced to synthesize proposed solutions to urban water issues, as identified by each project. The ongoing studies investigate: the current state of urban water systems (pressures, challenges); and socially viable and economically feasible pathways to improve the resiliency and co-benefits of urban water systems while meeting current and future needs.
- **Integrated Web Tool**: This tool is developed to enhance the capacity of decision makers to reach integrated decisions that foster One Water approaches and build sustainable urban water systems. The tool serves as a planning level tool to identify tradeoffs of integrative urban water management strategies considering economic, social, and environmental contexts. The tool is being piloted in UWIN regions with varying climatic conditions, infrastructure, decision drivers, and social preferences. Benefits and tradeoffs of various integrated water management strategies are assessed via indicators delivered by the Indicators task force.

Stakeholder Engagement

Interactions between UWIN researchers and water stakeholders from five regions (Southeast Florida, Sun Corridor, Mid-Atlantic, Pacific Northwest, and Front Range) have provided a basis for case studies on transitions toward sustainability. Analysis of qualitative data on pressures, states, and responses collected during interactions has provided insight into the challenging context of urban water management. Top pressures identified include climate change, aging infrastructure, water quality impairments, and funding limitations. Additionally, stakeholders described resistance to change and short-term perspectives among elected officials, limited understanding/awareness of water systems among decision makers, and lack of leadership on water issues as contributing to pressures. More than technological solutions, practitioners call for improved coordination in water management, strengthened communication with elected officials, and behavioral change among citizens.

The Network is currently conducting activities in collaboration with the Philadelphia Water Department (PWD) to develop a web-tool to evaluate and adapt co-benefits/triple bottom line analysis for use in PWD's planning analysis of alternative stormwater management infrastructure. This collaborative effort provides information on benefits and costs of green infrastructure to inform design criteria, regulations and incentive programs as well as support decision making and foster communication of benefits and costs of green infrastructure to decision makers, stakeholders and the public.

UWIN participated in a multi-institutional collaborative effort let by Brooklyn College of the City University of New York to evaluate the resiliency of the City's stormwater and flood control infrastructure to climate change and sea level rise. New York City governmental stakeholder partners included the Department of Environmental Protection (DEP), Mayor's Office of Resiliency (MOR), and Emergency Management (NYCEM). The study created a citywide Hydrologic and Hydraulic (H&H) model to model flooding from stormwater in NYC. Citywide flood exposure for twenty current and future storm scenarios were simulated. The impacts of flood exposure across representative neighborhoods in across NYC. The study identified grey, green, and hybrid infrastructural systems to reduce flood exposures at both citywide and at the neighborhood scale. The Stormwater Resiliency Plan was released by Mayor De Blasio in May (2021) and can be accessed here:
https://www1.nyc.gov/assets/orr/pdf/publications/stormwater-resiliency-plan.pdf

Undergraduate Research Program (URP)

The URP participants are given the opportunity to perform cutting edge, transdisciplinary research of immediate relevance to people in urban areas. Students with varying research interests – social sciences, natural sciences, engineering – are placed with a team of mentors at institutions in urban areas across the nation. The program starts and ends at Colorado State University, Fort Collins, Co. The UWIN URP program engages students in three strands of activities:

- Cutting Edge Independent Research Projects
- Reflective Practice and Training Activities
- Transdisciplinary Research Activities in Urban Water Sustainability

Diversity Program

The Diversity Recruitment and Retention supplement was awarded to Adriana Arcelay for the 2019-2020 academic year at the University of Arizona. An ideal candidate for broadening participation from traditionally underrepresented minority groups, Ms. Arcelay is a female, African American student from a lower income background currently pursuing an MS in Hydrology at the University of Arizona. Through the supplemental UWIN support Adriana has worked on extending understanding of flood risks in rivers with non-stable beds (contributing to UWIN Project B2-2). Adriana was trained to use climate model outputs as inputs to hydrologic and hydraulic models and to estimate uncertainty in flood predictions. Her research and training is overseen by UWIN-UAZ PI Thomas Meixner, Adriana also received one semester TA position and tuition remission from the University of Arizona Department of Hydrology and Atmospheric Sciences.

To further the diversity goals set established by the Network, the 2020 URP cohort included three Hispanic students and one African American student, as well as students from institution types ranging from R-1 (e.g., UC Berkeley) and HBCU (e.g., Howard) to small liberal arts schools (e.g., St. Olaf's).

Citizen Science Program

- **Green Infrastructure Rapid Assessment (GIRA):** UWIN collaborated with Earthwatch and HSBC on the Green Infrastructure Rapid Assessment (GIRA) project with over 200 participants in 4 US cities (New York City, Buffalo, Chicago, San Francisco) and 2 cities in Canada (Toronto, and Vancouver). Data were collected from 71 bioswales (some bioswales were visited more than once). Approximately 177 datasets were collected across all study bioswales over the life of the project, including infiltration rate, soil classification, bioswale features and mapping, and in situ data collected via Arduino sensor installation.

- **Off the Roof:** The project investigates roof runoff water quality to inform treatment targets for different end-uses. Roof runoff was collected from 7 households for 4 precipitation events in Fort Collins, Tucson, Miami, and Baltimore. Results indicate that roof runoff chemical and microbial quality is highly variable across regions and sampling seasons. extensive planning and coordination is needed to enable successful roof runoff collection from the four study cities.

TRAINING & PROFESSIONAL DEVELOPMENT

Undergraduate Research Program (URP)

The UWIN URP was a nine-week program that took place in summers of 2016-2020, with 9-10 students participating each summer (48 in total). While the 2020 program was entirely virtual, students in the 2016-2019 programs spent the core 8 weeks of the program in residence at host institutions across UWIN, conducting independent research with mentors, participating in the mentors' lab groups, and connecting to other students on campus. The program began with a Kickoff Meeting at CSU in Ft. Collins for team building, a Case Study of a local water sustainability issue, and orientation to the summer program, and ended with a Wrap-up meeting back at CSU held in conjunction with the annual meeting of UWIN. There, students presented research posters and the culminating product from their Case Study, cemented friendships with their cohort, and made connections with scientists from across the network. During the 8 week research period, the URP Program Coordinator organized twice-weekly sessions that included skill and career development workshops, transdisciplinary research in action seminars and open discussions of current issue (e.g., racial justice and the pandemic were important topics in the 2020 program). The Coordinator and Program Director (Berkowitz) provided one-on-one support to students and mentors throughout the program.

Over the 5 years, the UWIN URP received 1624 applications (averaging 325 per year), indicating a very high level of interest among undergraduates for this kind of network-based research experience. The applicant pool was 23% underrepresented minorities (URM), 60% female and included students from a wide range of majors and institutions types. Our 48 participants included 79% women, 33% Latino/Hispanic, 13% African American/black, and 8% more than one race (54% URM total) with 44% engineering, 31% environmental studies or social science and 25% environmental science majors. Thirty-eight mentors from 16 institutions participated in the program, including 16 women (42%) – low compared to our participant pool, but high given the current 11% of employed women with doctorates in engineering.

Outcomes are gauged with pre- and post-program student surveys, post-program mentor surveys, periodic alumni surveys, focus group meetings with students and mentors (separately) and from student work products (research proposals and presentations, final posters and paper, etc.). Students were extremely positive about the overall UWIN URP. Students and mentor reported impressive student gains in all targeted growth areas, including 1) agreed or strongly agreed on positive impact on all goals; 2) using retrospective pre-post self-assessment of the complex problem-solving for sustainability competencies from Wiek et al. (2011) showed significant gains for all 8 skills with impressive effect sizes (.51 to .62 within a 5 point scale); 3) Students' Transdisciplinary Orientation Scores (Misra et al. 2015) went up significantly; 4) self-assessed confidence in the research, social and communication skills targeted by the program increased significantly for all cases, with the largest gains for research skills and for communicating with scientists both within and beyond their discipline; and finally, 5) significant gains for vocational skills, with greatest gains in confidence for making a well-informed decision about pursuing a career in water sustainability and understanding the rewards and challenges of a career as a research or scholar.

All of the UWIN URP students presented research posters at the UWIN Annual Meeting which were extremely well received, with several of the student awards going to their posters in a combined undergraduate/graduate student competition one year. All but 5 of the 48 participants produced comprehensive final reports, many have given presentations at professional society meetings, and to date there are 12 published journal articles with UWIN URP co-authors and another 3 in preparation or

review. UWIN URP alumni have gone on to a diversity of academic and career paths. Our most recent information found 60% employed and 27% in graduate school – all in science or engineering.

Graduate Students

Over 80 graduate students were involved in UWIN-related research activities over the lifespan of the project. While not all students were funded directly by the project, all students contribute to the UWIN SRN goals and objectives. The project has generated research resulting in the completion of 16 Master's theses and 26 Doctoral dissertations. In addition, three undergraduate theses were also completed with support from the UWIN SRN.

In addition, UWIN students received training and mentorship in conducting complex, interdisciplinary research. Examples of training and scholarship opportunities include:

- Student training on presentations at professional meetings and conferences
- Student training and mentorship in preparation of project results and manuscripts for academic journal submissions
- Mentorship and supervision to complete PhD dissertation and M.S. thesis projects
- Interdisciplinary team science training for graduate students
- Professional development for graduate student with job applications for faculty positions and preparation for on-campus interviews
- Graduate students training in analysis of survey data; satellite data interpretation and analysis; plant biodiversity surveys; econometrics; One Water approaches; microbial analysis; stormwater control measures; water reuse; water demand reduction strategies; multi-objective optimization; and use of sustainability indicators to measure co-benefits of water conservation and reuse strategies
- Training opportunities for data science, big-data analytics, data integration, and computational statistics
- Training opportunities for decision making under deep uncertainty
- Training opportunities in network analyses research
- Training opportunities human subjects research ethics, interview design, and interview administration
- Collaborative science activities across a geographically distributed and interdisciplinary team

Harlan's Water Equity Team (Project C3-1) engaged five graduate students and two postdoctoral associates, who are conducting water-related research at Northeastern University. Projects include coastal resiliency on the Atlantic and Gulf Coasts, microplastics pollution in oceans, and public policies that contribute to water unaffordability for low-income households.

Postdoctoral Scholars

Fifteen postdoctoral researchers were involved with UWIN research and training activities over the lifespan of this project. Several postdoctoral researchers were promoted to faculty positions as described below.

Post-doctoral Scholar Promotions

- Post-doctoral scholar Dr. Ashley Broadbent, who was previously promoted to Assistant Research Professor, has successfully secured employment at the National Institute of Water and Atmospheric Research (NIWA) in his homeland of New Zealand in 2020
- Michelle Stuhlmacher secured employment as Assistant Professor at DePaul University starting Fall semester of 2020

- Postdoctoral scholar Dr. Michael Bozlar started as tenure track faculty at University of Texas, Arlington
- Maider Llaguno Munitxa joined Northeastern University as a tenure track assistant professor in the fall 2020 (School of Architecture)
- Jessica Bolson was hired as an Instructor then further promoted to Assistant Professor at Florida International University in 2019
- Qi Li started as Assistant Professor in the CEE department at Cornell University in 2019
- Jiachuan Yang started as Assistant Professor at the Hong Kong Institute of Science and Technology in 2019
- Theo Lim started as an Assistant Professor in Urban Affairs and Planning at Virginia Tech in 2019
- Scott Krayenhoff transitioned to a tenure-track position at Guelph University in 2018
- Alex Maas transitioned to Assistant Professor in Agricultural Economics and Rural Sociology at the University of Idaho in 2018

Professional Development

UWIN sponsored four professional development workshops for Network participants. Two were focused on the development of capacities for managing complex scientific research networks (UWIN researchers and students) and two were focused on interdisciplinary knowledge integration (UWIN graduate and undergraduate students).

Nine Team Science Adaptive Management Skills Training (TSAM) workshops were led by Alicia Lanier of Lanier Consulting as part of the UWIN regional stakeholder meetings held in 2016 at five UWIN research regions (Southeast Florida, Sun Corridor, Mid-Atlantic, Northwest Pacific and Front Range) and in 2017 at four UWIN research regions (Southeast Florida, Sun Corridor, Mid-Atlantic, Northwest Pacific).

Two Employing Model-Based Reasoning in Socioenvironmental Synthesis (EMBeRS) workshops for graduate and undergraduate students were led by Deana Pennington, the Principal Investigator of the EMBeRS Innovations in Graduate Education NRT (DGE-1545404) and were held as part of the UWIN annual meetings in 2019 and 2020.

A total of 74 individuals participated in the TSAM workshops: 23 principal investigators, 5 post-doctoral researchers, 38 graduate students, 2 undergraduate students and 7 research/administrative staff across the five UWIN research regions. These participants learned and participated in methods and techniques for managing collaborative interdisciplinary research designed to discover and promote sustainable urban water solutions through the development of critical knowledge and skills in adaptive management, team science, and facilitation. Majorities of participants reported that the workshop influenced their thinking about collaborative research and that they found the methods and techniques useful in their own interdisciplinary research collaborations.

A total of 37 individuals participated in the EMBeRS workshops: 18 graduate students and 19 undergraduate research program students. The students learned and practiced a structured approach to transdisciplinary research collaboration that allowed them to effectively communicate without jargon and find ways of creating new research design paradigms through connecting different knowledge and methods. They learned how their research connected in a One Water Approach and found areas across UWIN's research thrusts where others' research outputs would be useful for their analyses and where their research outputs would be useful input for others' projects. Majorities of students said they would use the approach to frame and explain their own research to others, collaborate on research, use in working with stakeholders, use in informal discussions with colleagues, and use to explain their research to potential employers (graduate students) or apply to graduate school (undergraduate students).

Majorities of students also said the workshops could lead to new or enhanced collaborations within UWIN.

Citizen Science

The participating citizen scientists in both the GIRA and Off the Roof projects have learned about water in urban systems. GIRA participants have learned how GI works and the relationship between flood water, sewer overflows and water quality in cities. One MS student (Samantha Swartz at U AZ) has been supported for her work on the project. Both projects concluded during the course of this reporting period and results are being disseminated in relevant presentations and publications.

DISSEMINATION OF RESULTS

The UWIN research and education team members actively disseminated the products of research, education, and engagement activities via publication of high impact journal papers, presentations at various conferences, and invited lectures/seminars. These products include:

- 221 high impact journal publications available at https://www.zotero.org/groups/738723/urban_water_innovation_network_uwin/library
- 46 PhD dissertations, Master's and undergraduate theses
- 9 book chapters
- 337 conference papers/posters and presentations
- 3 patents, 6 IP disclosures, and 12 software copyrights
- 89 outreach and print materials available at https://erams.com/UWIN/print-materials/
- 26 software and modeling tools
- 4 websites
- 51 webinars available at https://www.youtube.com/channel/UC7nNrIUznXii6_u0axbhQrA
- 40 datasets available online at https://erams.com/UWIN/data/

A comprehensive list of these products is available from the Products Section of this progress report.

UWIN has forged partnerships with water stakeholders in 15 cities to conduct transdisciplinary research and disseminate actionable science results to communities. For example, our team led the New York City Stormwater Resiliency Study funded by NYC DEP and Mayor's Office to assess flood risks in the City and identify effective interventions. Similarly, ongoing stakeholder engagement is conducted in Philadelphia to develop a web-tool to evaluate and adapt co-benefits/triple bottom line analysis for use in PWD's planning analysis of alternative stormwater management infrastructure.

UWIN has also developed datasets and modeling tools that are available ale to the broader community as open-source information. Our tools are currently used by thousands of annual users. Continuous support for these tools is provided to expand their application in other regions and studies.

Convergent Research in Action - Stormwater Resiliency Study

The City of New York (NYC) governmental stakeholders, including the Department of Environmental Protection, Mayor's Office of Resiliency, and Emergency Management recognize the current and rising threat posed by urban and compound flooding. As such there are several initiatives underway that aim to improve service reliability and resiliency of stormwater systems by planning and implementing effective and viable strategies across the city. Integrated stormwater management can address urban and compound flooding through a planning and implementation approach for long-term resiliency and reliability that meets both community and ecosystem needs. To support this work, NYC must understand complex and evolving urban flooding drivers, as well as how they may be mitigated by stormwater management practices. City stakeholders are beginning to address these issues on a local level through projects such as the Cloudburst Resiliency Study, but many gaps in knowledge remain. The UWIN-leveraged Citywide Stormwater Resiliency Study is an excellent example of convergent research that helped to address these gaps in knowledge. Outputs of the study included the creation of a citywide Hydrologic and Hydraulic model (see NYC Stormwater Resilience Plan) to simulate flooding for 20 storm scenarios and to assess exposures and risks associated with this flooding on both the citywide and neighborhood scales. Additionally, four intervention scenarios were developed and tested to assess the impacts of these interventions on five of the storm scenarios (see The New Normal Report).

Critical to the delivery of the project outputs was co-production with NYC agency Stakeholders. The Stormwater Resiliency Study researchers consulted extensively with NYC DEP and NYC Mayor's Office project leadership via a highly iterative process throughout the project (i.e,. informal weekly meetings and more formal Agency Stakeholder Workshops with key agency leadership). The goals of the Agency Stakeholder Workshops were to a) elicit detailed feedback on project progress, b) learn more about respective agency needs to ensure that project outputs align with these needs, and c) establish a long term dialogue on integrated stormwater management in NYC that cuts across agency sectors.

COLLABORATORS & PARTNERS

Partners

During the course of this project, **UWIN has engaged over 80 organizations** including 35 academic institutions, 19 governmental agencies, 13 non-profit organizations, 10 utility partners, 4 industrial firms, and 3 consultants. A summary of our partners is provided below.

Name	Organization Type	Location
Arizona Department of Health Services	State or Local Government	Phoenix, AZ
Arizona State University (UREx SRN, UAHS, 3HEAT)	Academic Institution	Tempe, AZ
AT&T	Industrial or Commercial Firms	Dallas, TX
Athens-Clarke County, GA	State or Local Government	Athens, GA
Baltimore County Dept. of Environmental Protection & Sustainability	State or local Government	Baltimore, MD
Baltimore County, MD Dept. of Public Works/Dept of Env Protection & Sustainability	State or Local Government	Towson, MD
Brooklyn College - City University of New York	Academic Institution	Brooklyn, NY
California State Water Resources Control Board	State or Local Government	Los Angeles, CA
Carollo Engineers, Inc.	Consultant	Los Angeles, CA
Cary Institute of Ecosystem Studies	Academic Institution	Millbrook, NY
Chattahoochee River Keeper	Non-profit	Charity, GA
City of Atlanta Watershed Management	State or Local Government	Atlanta, GA
City of Charlotte, NC	State or Local Government	Charlotte, NC
City of Fort Collins	State or Local Government	Fort Collins, CO
City of Miami	State or Local Government	Miami, FL
City of Moscow	State or Local Government	Moscow, ID
City of Phoenix	State or Local Government	Phoenix, AZ
City of Tempe	State or Local Government	Tempe, AZ
Colorado School of Mines	Academic Institution	Golden, CO
Colorado State University	Academic Institution	Fort Collins, CO

Decision Center for a Desert City (DCDC, phase III)	Academic Institution	Tempe, AZ
Denver Metro Wastewater Reclamation District	Utility	Denver, CO
Denver Water	Utility	Denver, CO
Earthwatch Institute	Non-profit	Boston, MA
Exxon Mobil	Industrial or Commercial Firms	Irving, TX
First Street Foundation	Non-profit	New York, NY
Florida International University	Academic Institution	Miami, FL
Fort Collins Utilities	Utility	Fort Collins, CO
Freshwater Simulations	Industrial or Commercial Firms	Portland, OR
Georgia Association of Floodplain Management	State or local Government	Atlanta, GA
Georgia State University	Academic Institution	Atlanta, GA
GreenRoots	Non-profit	Chelsea, MA
Howard University	Academic Institution	Washington, DC
Institute for Sustainable Infrastructure	Non-profit	Washington, DC
Kounkuey Design Initiative	Non-profit	Los Angeles, CA
Lanier Consulting, LLC	Consultant	Miami, FL
Maricopa County Department of Public Health	State or Local Government	Phoenix, AZ
McCormick-Taylor Consultants	Consultant	Baltimore, MD
Metro Water Reclaimation District	Utility	Denver, CO
Miami Beach Utility	Utility	Miami, FL
Miami/Dade County Water & Wastewater Dept.	Utility	Miami, FL
Michigan State University	Academic Institution	East Lansing, MI
Minnesota Dept. of Health	State or Local Government	Minneapolis, MN
Moscow Water	Utility	Moscow, ID

Nanjing University	Academic Institution	Nanjing, China
National Center for Atmospheric Research	Academic Institution	Boulder, CO
National Weather Service Phoenix Forecast Office	State or Local Government	Phoenix, AZ
Nature Conservancy Arizona	Non-profit	Phoenix, AZ
Northeastern University	Academic Institution	Boston, MA
Northeastern University School of Law	Academic Institution	Boston, MA
Oregon State University	Academic Institution	Portland, OR
Philadelphia Water Department	Utility	Philadelphia, PA
Pima County Wastewater	Utility	Tucson, AZ
Princeton University	Academic Institution	Princeton, NJ
RS&GIS (Michigan State University)	Academic Institution	East Lansing, MI
Sonoran Institute	Non-profit	Tucson, AZ
Southeast Florida Regional Climate Change Project	Non-profit	Miami, FL
SUEZ Water Technologies & Solutions	Industrial or Commercial Firms	Trevose, PA
Swiss Federal Institute of Technology Zurich, Switzerland	Academic Institution	Zurich, Switzerland
The Nature Conservancy	Non-profit	Phoenix, AZ
Torino Polytechnic	Academic Institution	Torino, Italy
Tucson Water	Utility	Tucson, AZ
United States Army Corps of Engineers	Federal Government	Mobile, AL
United States Army Corps of Engineers	Federal Government	Vicksburg, MS
University at Buffalo	Academic Institution	Buffalo, NY
University College London, UK	Academic Institution	London, England
University of Arizona	Academic Institution	Tucson, AZ

University of Baltimore Maryland County	Academic Institution	Baltimore, MD
University of California, Berkeley	Academic Institution	Berkeley, CA
University of California, Riverside	Academic Institution	Riverside, CA
University of Georgia	Academic Institution	Athens, GA
University of Idaho	Academic Institution	Moscow, ID
University of Miami	Academic Institution	Miami, FL
University of Oregon	Academic Institution	Eugene, OR
University of Pennsylvania	Academic Institution	Philadelphia, PA
University of Perugia	Academic Institution	Perugia, Italy
University of Reading	Academic Institution	Reading, UK
University of Texas at Dallas	Academic Institution	Dallas, TX
UREx Sustainability Research Network	Academic Institution	Tempe, AZ
US EPA	Federal Government	Cincinnati, OH
Vitalyst Health Foundation	Non-profit	Phoenix, AZ
Water Research Foundation	Non-profit	Alexandria, VA
Watershed Management Group	Non-profit	Tucson, AZ
Wayne State University	Academic Institution	Detroit, MI

Regional Stakeholder Advisory Committee Members

Front Range: Sarah Anderson, Kevin Bommer, Devon Buckels, Tom Cech, Melanie Criswell, David Erickson, Greg Fisher, Basil Hamdan, Bret Icenogle, Tracy Kaye, Jim McQuarrie, Gabriela Medina, Patrick Pfaltzgraff, Holly Piza, Dr. Florine P. Raitano, Reagan Waskom, Kevin Reidy.

Pacific Northwest: Rick Bastasch, Bobby Cochran, Jim Duggan, Stephanie Eisner, Allison Hensey, Johan Hogervorst, Hydrologist, Wayne C. Huber, Jim Meierotto, Brooke Mittermann, Karl Morgenstern, Alyssa Mucken, Bruce Roll, Carrie Sanneman, Greg Taylor, Dawn Uchiyama.

Mid-Atlantic: Kristin Baja, Jim Caldwell, Halle Van der Gaag, Jim George, Kim Grove, Benjamin H. Grumbles, Thomas Kiefer, John McCoy, Bill Stack, Steve Stewart, Anne Hairston-Strang, Frank Blanco, Jim DuBois, Kathy Chavez, Jeanne Jensen, Aminata Kilungo, Mark Hartman, Mark Holmes, Fernando Molina, Ken Seashole, Kieran Sikdar, Andy Terrey.

Southeast Florida: Jacob Coker-Dukowitz, Nichole L. Hefty, Morgan Hopkins, Jennifer Jurado, Amy Knowles, Dawn M. Meyers, Jayantha Obeysekera, Douglas Yoder.

Sun Corridor: Frank Blanco, Jim DuBois, Kathy Chavez, Jeanne Jensen, Aminata Kilungo, Mark Hartman, Mark Holmes, Mead Mier, Fernando Molina, Ken Seashole, John Shepard, Kieran Sikdar

New York: Pinar Balci, Chris Boyd, Stuart Brodsky, Edward Clerico, Simon Mettler, Philip Silva, Kenniff Vlada, Julie Welch, Michael Gubbins, Caitrin Cronin, Alan Cohn, Erin Morey, Susanne DesRoches.

Philadelphia: Dwayne Myers, Marc Cammarata, Dan Schupsky, Kelly Anderson, Stephen White, Adam Hendricks, Stephanie Chiorean, Peter Struck, Maria Antonia Andrews, Zhengxia Dou, Simon Richter Dave Arscott, William Braham, Scott Moore, Karl Russek, Erica DePalma, Carol Collier, Allison Lassiter, Russell Composto, Ken Steif, Meg Kramer, David Hewitt, Tom Daniels, Shu Yang Yang, Howard Neukrug, Swati Hegde, Julie Heffernan, Marilyn Howarth.

Citizen Science Program

Audrey Mohan (BSC), Rebecca Jorban (Rutgers Unv.), Rob Dunn (NC State Unv.), Jay Garland (EPA), Nichole Brinkman (EPA), Scott Keeley (EPA), Michael Jahne (EPA), Greg Newman (CSU/NREL), Diana Eddowes (EarthWatch), Jake Geddes (EarthWatch), Mark Chandler (EarthWatch), Anna Woodroof (EarthWatch), Lucy Triedman (EarthWatch), Caroline Nassif (EarthWatch), Caroline Dunn (EarthWatch), Gitte Venicx (EarthWatch), Paul Stanley (HSBC), Ruth Legg (HSBC), Andrew Greenspan (HSBC), Kelly Fisher (HSBC)

Undergraduate Research Program

Dr. Geoffrey Habron, Furman University, Greenville, SC; Dr. Deana Pennington, University of Texas at El Paso, El Paso, TX; Dr. Julia Svoboda Gouvea, Tufts University, Medford, MA; Dr. Kate Thompson, Griffith University, Australia; Dr. David Gosselin, University of Nebraska-Lincoln.

Other Collaborators

Dr. Fei Chen (NCAR), Mr. Mukul Tewari (IBM), Prof Sue Grimmond (Reading), Prof Nima Shokri (University of Manchester), Prof William Anderson (UT Dallas), Prof Marcus Hultmark (Princeton), Dr. Mark Chandler (Earthwatch Institute), Dr. William Eisenstein (UC Berkeley and ReNUWIt), Prof. John

McCray (Colorado School of Mines and ReNUWIt), Daniel Wright (UW – Madison), Dr. Jun Wang (Unv. Iowa), An Moynihan (Pima County Flood District), David Goodrich (ARS), Irene Ogata (City of Tucson), Lucero Radonic (Michigan St. Unv.), Jayantha Obeysekera (SFWMD), William V. Sweet (NOAA), Anne Miller (CO Dept. Local Affairs), Russ Sands (Brendle Group/CWCB), Zoe Hamstead (UREx SRN), Chris Wyczalkowski (UREx SRN), Craig Fugate (Metropolitan North Georgia Water Planning District), Todd Bridges (One Concern, Engineering with Nature, USACE), Susan Beck (Georgia Dept. of Transportation), Sean Gordon (Portland State University), Vivek Shandas (Portland State University).

IMPACTS

Principal Discipline(s)

The UWIN research and engagement activities to date have advanced fundamental knowledge about driving forces, pressures and responses that influence sustainability of urban water and linked systems. Primary scientific disciplines that are involved with these activities include: urban microclimate and heat islands; climate change and extreme events; urban water demand, alternative water sources and fit-for-purpose use; vulnerability to water shortage in a changing world; vulnerability to urban flooding; urban water pollution; urban biodiversity; urban water social and policy networks; social and environmental justice implications of urban water management and extreme events; and human health and wellbeing.

The UWIN research projects have culminated in collection and creation of an unprecedented amount of data about past and present states of urban water and linked systems at local, municipal and continental scales. Additionally, our team members have developed new modeling systems that enhance the predictive capacity to assess the effects of changes in population, land use, climate, and extreme events on the vulnerability of our communities to water shortage, flooding, water pollution, extreme heat, and loss of natural capital in cities. These modeling capabilities are being used to develop appropriate adaptation and mitigation strategies that improve access to safe and clean water, resilience to extreme events, and long-term reliability of water systems and services.

Fully Coupled Representation of Urban Microclimate and Water Cycle

We have created the most complete framework to date to simultaneously model the urban water cycle and demand, the urban climate, urban energy use, and interactions thereof. The framework is being used to answer the following questions that are of central importance in the discipline:

- How does the full coupling of WRF-UCM-ParFlow affect hydrological and climatological predictions in urban terrain?
- In dry periods, urban vegetation becomes water stressed and needs irrigation, which places additional demand on water supply. What is the likelihood of such dry periods occurring at present and how will this likelihood be influenced by future climate change?
- How do climatic and energy benefits of green infrastructure facilities balance against their potential water requirements across the six metro regions that are studied in the UWIN?
- What are the effects of impervious surface area and green infrastructure on the water table location and the vulnerability of urban areas to extreme heat and drought?
- How much urban water use variability can be attributed to climatic variability and how can water demand increases associated with climate extremes be reduced?
- How do urbanization patterns, density and spatial extent influence the response of a metropolitan region to climate extremes, and thus can urban planning be used to increase urban resilience?

Our efforts are the first to robustly address these questions.

These projects also elucidate and enhance understanding of the role of urban heat in driving heat-related health outcomes. The UWIN projects have made methodological advances for environmental health and health geography, and strategies for monitoring/modeling personal heat exposure in cities. Our goal is to explore and advance the notion of personal heat exposure as a useful measurement for informing urban sustainability practices and decision-making.

Urban Biodiversity
Our data collection and modeling studies have advanced the knowledge of urban biodiversity in the context of urban microclimate variability, water availability, and development patterns.

Urban Water Supply Infrastructure, Water Demand, Alternative Water Sources, and Fit-For-Purpose Use
We have characterized and estimated current and future water yield, water supply and water demand for the contiguous United States (CONUS) to explore the vulnerability of U.S. water supply systems to shortage. These data, modeling tools and analyses reveal the effects of urbanization and climate change on water scarcity, supply reliability, and resiliency.

The newly developed, calibrated and tested Integrated Urban Water Model (IUWM) provides a significant advancement of our predictive capability to assess urban water demand management strategies and fit-for-purpose use of alternative water sources. This model can inform estimates of reliability of water resources under varying scenarios of climate, population and land use change. This model can inform estimates of reliability of water resources under varying scenarios of climate, population, and land use change.

Moreover, guidance was developed for use of alternate water sources. This guidance has been used to develop regulation for onsite water systems in California and Colorado. Another four states have regulations underway that use the developed guidance (MN, OR, WA, and HI) and two states are considering regulations (TX and AK).

The UWIN team also investigates solutions that enhance the resilience trajectories of urban water infrastructure. For example, the knowledge about dynamic responses and interactions that shape the long-term performance of dual water distribution infrastructure was advanced, including:

- The trade-offs among implementation of dual distribution systems compared to the existing singular systems
- The life-cycle cost impacts of dual water distribution system implementation as well as the existing singular water distribution systems
- The trade-off among long-term performance reliability and life-cycle costs of implementation of dual distribution systems

We have developed data showing alteration in biogeochemical and hydrologic conditions in Green Infrastructure that appears to show a positive feedback loop, e.g. as plants grow organic matter is added and subsequently hydraulic properties are altered, which in turn encourages more plants to grow increasing organic matter.

Urban Floods
Floodplain management programs in the U.S. are widely regarded as being “broken”. Our projects advance fundamental understanding of urban floodplain hydraulics and methods for characterizing uncertainty in floodplain inundation mapping while challenging the antiquated, deterministic approaches that are entrenched in U.S. floodplain management programs.

We have also developed a coherent and rigorous analytical method to estimate future return period of different categories of coastal flooding under nonstationary sea level conditions. This theoretical advancement enabled an improved assessment of coastal flood risks under different sea level rise as

well as implementation of mitigation scenarios. We will next assess compounding risks from co-occurrence of storm surge and heavy precipitation.

Social and Policy Networks of Urban Water and Linked Systems
Our social, behavioral and economic research activities have created data and models that examine preferences and cognitive factors that influence decisions made within the urban water governance networks. These activities have improved our understanding of the determinants of consumer behavior and support for particular urban water management strategies and technologies, including discrepancies in how urban water innovations are perceived by different stakeholder groups. Methods are being developed that allow for simultaneous education and inquiry about adoption of new technologies, hence enabling collection of new information about individual preference and information seeking behaviors around water technologies.

Other Disciplines

Urban water and linked systems are under tremendous pressures due to limited resources and ever-increasing demands on existing systems. Population growth and urbanization influence the livability of our communities. Decisions about our water systems are made under deep uncertainty about future (e.g., climate) conditions. In response to these challenges, the UWIN research, education, and engagement programs create approaches that facilitate the transition from a "service provision" model for planning and management of water systems to a "resource management" model. The transdisciplinary UWIN activities explore technological, policy, institutional, and financial pathways toward sustainable management of water systems in a changing world. The SRN activities are conducted by researchers, scientists, students, and stakeholders from traditionally disparate disciplines, hence fostering cross disciplinary learning and innovation.

UWIN brings together perspectives and resources from 21 academic institutions with longstanding programs in water research and education, and close ties to water stakeholders across the U.S. The core competencies of our transdisciplinary team span geosciences; ecology; atmospheric sciences; water resources and environmental engineering; social, behavioral, economic and decision sciences; urban planning and design; real estate and urban economics; mathematics and statistics; and computer sciences. The partnership integrates the expertise of investigators from historically African-American and Hispanic serving institutions, as well as educational experts experienced in societal learning and innovative approaches to education from the Cary Institute of Ecosystem Studies.

The UWIN interdisciplinary research programs enables training researchers and scientists that are familiar and comfortable with scientific terminology, approaches, and techniques from traditionally disparate areas.

For example, as a result of Dr. Sharvelle's contribution to the development of a framework for decentralized non-potable water systems, a National Blue Ribbon Commission was formed to develop a Guidebook. That guidebook has been nationally disseminated. San Francisco Public Utilities Commission has used the framework to guide development of regulations for non-potable water systems. Other jurisdictions are also working toward implementing components of the framework into their regulatory process. Consistent national guidance on regulation of decentralized non-potable water systems can increase ease of adoption of these systems with the ultimate impact of use of more local water sources.

Integrated Assessment of Urban Water and Linked Systems
Significant advancements have been made to enable integration of data and information from various water and linked systems, sectors, and domains (technological, social/policy, and financial) towards integrated assessment of urban water systems. We have developed a framework entitled "Urban Water Sustainability Blueprint" that provides a systematic approach to identification of water challenges and priorities from different lenses and perspectives, including the triple bottom line (TBL) approach, risk-based approaches, and the Drivers, Pressures, States Impacts, Responses (DPSIR) assessment. The proposed assessment framework incorporates multiple, and often conflicting, criteria in the decision-making process to ensure social viability, economic feasibility, and environmental sustainability and resiliency of proposed urban water sustainability responses.

Stakeholders & Training
Our findings extend the existing literature to add that evolution in social readiness, in the form of increasing awareness and behavioral and attitudinal shifts, is also necessary for transitions to more integrated water management approaches. Our recently published work also provides an assessment of the utility of the Pressure-State-Response model in the context of integrated urban water management.

Citizen Science
Our Citizen Science program data will help advance the field.

Undergraduate Research Program
Students' research contributed to the scientific program of mentor scientists. Some broke new ground, some developed new methods and study designs, others brought in new data and insights. We encourage students to present their results at their home institutions and at regional and national meetings. We are also hopeful that students' projects will contribute to new proposals, new lines of inquiry and peer review publications.

Human Resources
The SRN activities engaged over 250 academic collaborators including nearly 70 faculty members (2 deans, 28 professors, 15 assistant professors, 7 associate professors, and 2 instructors) from 35 academic institutions with interdisciplinary expertise, as well was 14 research scientists, 83 graduate students, 71 undergraduate students, 15 postdoctoral research associates, six technicians and three staff scientists. In addition, numerous postdoctoral researchers were promoted to faculty positions during the course of this project.

The UWIN URP has been tremendously successful in recruitment of undergraduate students from underrepresented groups for summer research training opportunities. Similarly, our regional stakeholder engagement activities facilitate two-way interactions between regional urban water managers, planners and other stakeholders with the academic team members. More than 100 regional stakeholders have been involved in our regional stakeholders meetings, both informing and learning about UWIN activities and findings.

Physical Resources
The project contributes to the environmental Resources Assessment and Management System (eRAMS) cloud computing infrastructure at Colorado State University. The computing infrastructure powers a platform for development and deployment of web-based water analytics and computationally scalable and accessible data and analysis tools.

Institutional Resources

The project contributed to the establishment of the One Water Solutions Institute at Colorado State University. The mission of the Institute is to connect our world-class research with real-world water challenges. In partnership with public, private and non-government organizations, the activities of the Institute facilitate the transition to integrated resource management across the water, food, and energy sectors.

Information Resources

Project activities create data and modeling information that are used to quantify urban water sustainability indicators using the Water Connect App. The Water Connect App, maintained by the One Water Solutions Institute at CSU, provides a single source for sharing water-related data and other resources for member cities. Users can also publish resources using the Water Connect App. Water Connect recognizes that to achieve sustainable urban water management, scientists, engineers, water managers and citizens need to access disparate data sets in order to accurately view the complete picture and respond with appropriate solutions. Water Connect fosters collaboration and promotes information sharing throughout the water community. It allows users to add their own data sets to those already publicly available. The user can control access to their data sets through setting up user groups that allow access by invitation. The web portal provides the framework, tools and guidance to view urban water systems through several “lenses” that could include wastewater management, water supply and quality, flood protection, land use, equity, or community and environmental health. A user can add more data and therefore more “lenses”. Water challenges can no longer be addressed individually, but rather must be viewed as multi-dimensional challenges to a city with solutions developed with as many perspectives as possible. Water Connect allows communities to look at their water system through various perspectives and find innovative, dynamic solutions.

Technology Transfer

The project activities have resulted in 3 patents, 26 software technologies, and modeling tools, and 2 start-up companies. The project team members are actively pursuing additional support from the NSF iCORP and SBIR programs.

Impact on Society Beyond Science & Technology

Our regional stakeholder engagement activities engage communities across the U.S. to increase social readiness, in the form of increasing awareness and behavioral and attitudinal shifts, requisite to the transitions from management of water systems in silos to an integrated approach. Our recently published work also provides an assessment of the utility of the Pressure-State-Response model in the context of integrated urban water management.

UWIN will lead urban sustainability efforts by producing findings that alter development trends of cities across the U.S. and around the world. Achieving sustainability in urban water systems presents a problem of coupled natural-built systems that requires insights into mechanisms of transition from knowledge to action. We intend to build that linkage by focusing on the integration of coupled urban water systems to produce a toolbox of solutions that will reverberate across other systems, such as urban ecosystems, economies, and arrangements for environmental justice and equity.

The Network will result in establishment of six regional urban water sustainability hubs in highly populated urban regions across the U.S. Through time, these regional hubs, with strong network interconnectivity amongst its nodes, will serve as innovation centers to help communities transition to sustainable management of water resources. Our strategic partnership with other national and international networks involved with urban sustainability will extend our reach to more than 100 cities around the world. A key impact of UWIN is development of an Urban Water Sustainability Blueprint that is vetted by stakeholders across the U.S. and globally. This novel and transformative Blueprint will foster adaptive societal learning and assessments in response to changes in pressures on water systems to maximize resilience and co-benefits.

The global impact of this SRN can occur from the cascading effects of institutions working with other institutions in a global network focused on sustainability of urban water systems. The complexity of these systems defies stovepipe thinking and requires a systems approach. By developing the intellectual framework and messaging required to inform and build capacity among other institutions, the global impact can be large and sustained. We will develop a globally prominent Urban Water Sustainability Hub using the Water Connect App that fosters communication and exchange of knowledge, data, and tools throughout the global community.

To date, UWIN has engaged more than 80 graduate students, nearly 70 faculty, and over 45 professional staff (e.g., postdoctoral research associates, staff scientists, technicians) and several early career scientists from diverse backgrounds in research, outreach, education, and broadening participation of network activities. The Network has provided research opportunities for over 70 undergraduate students with diverse backgrounds via a creative interdisciplinary undergraduate research program.

PERSONNEL

The SRN activities engaged over 250 academic collaborators including nearly 70 faculty members (2 deans, 28 professors, 15 assistant professors, 7 associate professors, and 2 instructors) from 35 academic institutions with interdisciplinary expertise, as well was 14 research scientists, 83 graduate students, 71 undergraduate students, 15 postdoctoral research associates, six technicians and three staff scientists.

First Name	Last Name	Project Role
Jumana	Alja'fari	Graduate student (research assistant)
Harrison	Ambrose	Undergraduate student
Abbeygail	Anders	Undergraduate student
Jack	Anderson	Graduate student (research assistant)
Riley	Andrade	Graduate student (research assistant)
Mazdak	Arabi	Professor
Adriana	Arcelay	Graduate student (research assistant)
Zach	Argo	Undergraduate student
Dorit	Aviv	Graduate student (research assistant)
Koroles	Awad	Graduate student (research assistant)
Mary Lynn	Baeck	Research Scientist
Michael	Barnes	Research Scientist
Kiernan	Bartlett	Undergraduate student
Giovana	Batista	Graduate student (research assistant)
Eliza	Benites-Gambirazio	Graduate student (research assistant)
Lena	Berger	Postdoctoral
Alexandra	Berk	Undergraduate student
Alan	Berkowtiz	Dean
Sierra	Bettis	Undergraduate student
Aditi	Bhaskar	Assistant Professor
Brian	Bledsoe	Professor
Annie	Block	Undergraduate student
Jessica	Bolson	Instructor
Dorothy	Borowy	Graduate student (research assistant)
Elie	Bou-Zeid	Professor
Theodore	Boyomo	Graduate student (research assistant)
Aldo	Brandi	Graduate student (research assistant)
Allan	Branscomb	Research Scientist
Kenneth	Broad	Professor
Ashley	Broadbent	Assistant Professor
Alexander	Brown	Undergraduate student
Amanda	Bruno	Graduate student (research assistant)
Kevin	Burgio	Staff Scientist (doctoral level)
Kati	Burton	Undergraduate student
Isabella	Catalano	Undergraduate student

Allison	Cerlanek	Undergraduate student
Analit	Chambi-Rojas	Undergraduate student
Elana	Chan	Undergraduate student
Molly	Chaney	Graduate student (research assistant)
Amber	Chau	Undergraduate student
Camille	Chaudron	Staff Scientist (doctoral level)
Jacquelyn	Chavez	Undergraduate student
Kianwee	Chen	Postdoctoral
Chingwen	Cheng	Assistant Professor
Jennifer	Cherrier	Professor
Matt	Chiavatta	Undergraduate student
Cibi	Chinnasamy	Graduate student (research assistant)
Michelle	Church	Graduate student (research assistant)
Eli	Claggett	Undergraduate student
Stephanie	Clark	Graduate student (research assistant)
Jeanne	Cole	Graduate student (research assistant)
David	Conklin	Consultant
Theresa	Connor	Other Professional
Lauren	Contorno	Graduate student (research assistant)
Ryan	Correa	Undergraduate student
Alycia	Crall	Research Scientist
Kevin	Credit	Graduate student (research assistant)
Mike	Crimmins	Professor
Jennifer	Dargin	Graduate student (research assistant)
Matt	Darrah	Undergraduate student
Olaf	David	Research Scientist
Tyler	Dell	Graduate student (research assistant)
Donya	Dezfooli	Graduate student (research assistant)
Rachel	Domond	Undergraduate student
Alisen	Downey	Graduate student (research assistant)
Andre	Dozier	Research Scientist
Steve	Drake	Other Professional
David	Dziubanski	Postdoctoral
Erica	Edwards	Undergraduate student
Emilia	Emilia Suarez	Undergraduate student
Lori	Emler	Graduate student (research assistant)
Chris	Enright	Instructor
Mohamed	Fawzy	Graduate student (research assistant)
Nickolas	Faynshteyn	Graduate student (research assistant)
Yaolin	Fennell	Assistant Professor
Brian	Fulfrost	Technician
Kelsi	Furman	Graduate student (research assistant)
Tiajahlyn	Furr	Undergraduate student

Canon	Furth	Graduate student (research assistant)
Erika	Gallo	Professor
Alfy Joseph	George	Graduate student (research assistant)
Matei	Georgescu	Associate Professor
Andrea	Gerlak	Professor
Hamidreza	Ghaffari-Nazarlou	Graduate student (research assistant)
Mahshid	Ghanbari	Postdoctoral
Ahmed	Gharib	Graduate student (research assistant)
Ahmed	Gharib	Graduate student (research assistant)
Charles	Glass	Professor
Katie	Glodzik	Postdoctoral
Edna Liliana	Gomez	Graduate student (research assistant)
Vanessa	Gomez	Undergraduate student
David	Gosselin	Professor
Fiona	Greer	Graduate student (research assistant)
Hattie	Greydanus	Undergraduate student
Neil	Grigg	Professor
Phil	Guertin	Professor
Hongshan	Guo	Graduate student (research assistant)
Neha	Gupta	Graduate student (research assistant)
Petek	Gursel	Postdoctoral
Marlene	Guzman	Undergraduate student
Geoffrey	Habron	Professor
Roy	Haggerty	Dean
Holly Yaryan	Hall	Graduate student (research assistant)
Sharon	Harlan	Professor
Hadi	Heidari	Graduate student (research assistant)
Chelsey	Heiden	Graduate student (research assistant)
Adam Douglas	Henry	Associate Professor
Victoria	Hermosilla	Graduate student (research assistant)
Manny	Herrera	Undergraduate student
Selena	Hinojos	Undergraduate student
David	Hondula	Assistant Professor
Arpad	Horvath	Professor
Nicholas	Houcois	Undergraduate student
David	Hulse	Professor
Kyotaek	Hwang	Postdoctoral
Peter	Ibsen	Graduate student (research assistant)
Gabrielle	Jawer	Undergraduate student
Darrel	Jenerette	Professor
Kimberly	Jones	Professor
Tiffany	Justice	Undergraduate student
Alanna	Kaiser	Undergraduate student

Theo	Keelye-LeClaire	Undergraduate student
Timothy	Kirby	Graduate student (research assistant)
Yoganand	Korgaonkar	Postdoctoral
Scott	Krayenhoff	Assistant Professor
Dion	Kucera	Graduate student (research assistant)
Mandla	Kunnie	Undergraduate student
Liza	Kurtz	Graduate student (research assistant)
Jeff	Kwan	Graduate student (research assistant)
Rod	Lammers	Postdoctoral
Alicia	Lanier	Consultant
Gina	Lee	Graduate student (research assistant)
Joome	Lee	Graduate student (research assistant)
Dave	Leston	Professor
Qi	Li	Graduate student (research assistant)
Theodore	Lim	Assistant Professor
Maider	Llaguno Munitxa	Postdoctoral
Aude	Lochet	Research Scientist
Brianne	Logasa	Undergraduate student
Alexander	Maas	Assistant Professor
Elizabeth	Mack	Associate Professor
Galen	Macpherson	Graduate student (research assistant)
Liz	Mariluz	Undergraduate student
Laura	Marlowe	Undergraduate student
Mariana Sofia	McGoffin Rodriguez	Undergraduate student
Isabel	McKnight	Undergraduate student
Lolya	McWest	Undergraduate student
Laura	Medwid	Graduate student (research assistant)
Forrest	Meggers	Assistant Professor
Thomas	Meixner	Professor
Samuel	Melzter	Undergraduate student
Coleman	Merchant	Technician
Robert	Meyer	Professor
Ariane	Middel	Assistant Professor
Krzysztof	Miezgiel	Undergraduate student
Andy	Miller	Professor
Laura	Miller	Undergraduate student
Sarah	Millonig	Other Professional
Jeff	Moeller	Other Professional
Fatuma	Mohamed	Undergraduate student
Ali	Mostafavi	Assistant Professor
Mohamed	Moustaoui	Associate Professor
Lianzheng	Mu	Research Scientist
Takondwa	Musa	Undergraduate student

Melanie	Nagel	Postdoctoral
Michael	Neale	Graduate student (research assistant)
Victoria	Nelson	Undergraduate student
Greg	Newman	Research Scientist
Maggie	O'Connor	Undergraduate student
Kiera	O'Donnell	Graduate student (research assistant)
Hamidreza	Omidvar	Graduate student (research assistant)
David	Ortiz	Undergraduate student
Shirley	Papuga	Associate Professor
Saloni	Patel	Graduate student (research assistant)
David	Patterson	Other Professional
Binaya	Paudel	Undergraduate student
Jose	Pillich	Technician
Gary	Pivo	Professor
Mary	Plauche	Undergraduate student
Kayla	Pope	Undergraduate student
Amber	Pulido	Undergraduate student
Roshan	Puri	Graduate student (research assistant)
William	Rainey	Graduate student (research assistant)
Sumedh	Rao	Other Professional
Kambiz	Rasoulkhani	Graduate student (research assistant)
Kyle	Redican	Graduate student (research assistant)
Nia	Rene	Graduate student (research assistant)
Julie	Ripplinger	Postdoctoral
Mia	Rochford	Undergraduate student
Tyler	Rockhill	Graduate student (research assistant)
Marcia	Rojas	Undergraduate student
Ashley	Rolon-Marlowe	Undergraduate student
Laura	Rosenbauer	Undergraduate student
Sean	Rucewicz	Technician
Paula	Rueda Villamil	Undergraduate student
Young-Hee	Ryu	Postdoctoral
Laura	Salazar	Graduate student (research assistant)
Luis	Salgado	Undergraduate student
Andres	Sanchez	Graduate student (research assistant)
Mary	Santelmann	Associate Professor
Mariana	Sarango	Graduate student (research assistant)
Karleene	Schindler	Other Professional
Jason	Schlottman	Undergraduate student
Ema	Schwartz	Undergraduate student
Haley	Selsor	Undergraduate student
Omar	Shahab	Graduate student (research assistant)
Sybil	Sharvelle	Professor

Xin	Shu	Graduate student (research assistant)
Julia	Signell	Technician
James A.	Smith	Professor
Brianne	Smith	Assistant Professor
Karla	Smith	Graduate student (research assistant)
Sheila	Solios-Arroyo	Undergraduate student
Clark	Stephanie	Graduate student (research assistant)
Philip	Stoker	Associate Professor
Jennifer	Stokes-Draut	Research Scientist
Michelle	Stuhlmacher	Graduate student (research assistant)
Yibing	Su	Graduate student (research assistant)
Mike	Sukop	Professor
Nadia	Sultan	Undergraduate student
Laura	Supple	Undergraduate student
Chris	Swan	Professor
Samantha	Swartz	Undergraduate student
Fatima	Taha	Graduate student (research assistant)
Michelle	Talal	Graduate student (research assistant)
Mahdad	Talebpour	Graduate student (research assistant)
Michael	Tchintcharauli-Harrison	Graduate student (research assistant)
Erica	Teitelbaum	Graduate student (research assistant)
Kate	Thompson	Research Scientist
Kyle	Traff	Technician
Galen	Treuer	Graduate student (research assistant)
Ales	Urban	Postdoctoral
Joe	Vacante	Research Scientist
Kellie	Vache	Assistant Professor
Jorge	Valdes	Undergraduate student
Miguel	Valencia	Undergraduate student
Jennifer	Vanos	Assistant Professor
Shirley	Vincent	Consultant
Audrey	Vogel	Undergraduate student
Meng	Wang	Research Scientist
Zhihua	Wang	Assistant Professor
Chenghao	Wang	Graduate student (research assistant)
Diane	Waweru	Undergraduate student
Claire	Welty	Professor
Jonah	White	Graduate student (research assistant)
Tyler	Wible	Other Professional
Adrian	Wilcox	Graduate student (research assistant)
Elisabeth	Wilder	Graduate student (research assistant)
Madison	Wimberly	Undergraduate student
Benjamin	Wostoupal	Graduate student (research assistant)

Sarah	Wrase	Graduate student (research assistant)
Mary	Wright	Graduate student (research assistant)
Maria	Wright	Research Scientist
Long	Yang	Postdoctoral
Jiachuan	Yang	Staff Scientist (doctoral level)
Earl	Zedd	Undergraduate student
Einara	Zhan	Graduate student (research assistant)

PRODUCTS

Product Summary (2015 – 2022)

Product	Total
Book Chapters	9
Journal Articles	221
Conference Presentations	337
Patents	3
Thesis/Dissertations	46
Technologies & Models	26
Websites	4
Webinars	51
Outreach Materials	89
Data	40
Invited Seminars & Lectures	30
Special Reports	4
Press Releases/News Articles	36

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New York, NY: Routledge. ISBN 9781032155975 https://www.routledge.com/Routledge-Handbook-of-Resilient-Thermal-Comfort/Nicol-Rijal-Roaf/p/book/9781032155975

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Conference Presentations

1. Aljafari, J., Sharvelle, S., "A Citizen Science Approach to Characterize the Microbial Quality of Roof Runoff", Hydrology Days, Fort Collins, CO. (March 2021).
2. Alja'fari, J., Sharvelle, S., Crall, A., Newman, G. (2019) "Off the Roof: A Citizen Science Project to Measure the Microbial Characteristics of Roof Runoff", Hydrology Days, Fort Collins, CO

3. Anderson, Jack - Bioswales: Benefit or Burden?, Presentation at El Dia Del Agua y la Atmosfera, Department of Hydrology and Atmospheric Sciences, Tucson AZ, University of Arizona April 9,2018.
4. Anderson, Jack, Meixner Thomas, 2017, Urban bioswale characterization and design evaluation El Dia Del Agua Y Atmosfera, University of Arizona, Tucson, AZ March 27, 2017.
5. Arabi, M., Dozier, A.Q. *Combatting declining agricultural production in rapidly urbanizing semi-arid regions*. University Council on Water Resources National Institutes of Water Resources, Fort Collins, CO, June 13-15, 2017.
6. Arabi, M., Dozier, A.Q., Wostoupal, B. *Hydroeconomic modeling framework for assessing vulnerability to water demands in arid regions*. American Society of Civil Engineers, World Environmental and Water Resources Congress, Sacramento, California, May 21-25, 2017.
7. Arcelay, Adriana- Investigating impacts of projected climate change on flood risk in urban areas located along river channels, Presentation at El Dia Del Agua y la Atmosfera, Department of Hydrology and Atmospheric Sciences, Tucson AZ, University of Arizona March 25, 2019.
8. Aviv, Dorit, and Forrest Meggers. 2017. "Cooling Oculus for Desert Climate – Dynamic Structure for Evaporative Downdraft and Night Sky Cooling." Energy Procedia, CISBAT 2017 International ConferenceFuture Buildings & Districts – Energy Efficiency from Nano to Urban Scale, 122 (September): 1123–28. https://doi.org/10.1016/j.egypro.2017.07.474.
9. Aviv, D., Houchois, N., & Meggers, F. (2019). Thermal Reality Capture. Proceedings of the 39th Annual Conference of the Association for Computer Aided Design in Architecture (ACADIA), 338–345. http://papers.cumincad.org/cgi-bin/works/Show?acadia19_338
10. Aviv, Dorit, Maryam Moradnejad, Aletheia Ida, Zherui Wang, Eric Teitelbaum, and Forrest Meggers. 2020. "Hydrogel-Based Evaporative and Radiative Cooling Prototype for Hot-Arid Climates." In SimAUD 2020, 273–80.
11. Aviv, D., Hou, M., Teitelbaum, E., Guo, H., & Meggers, F. (2020). Simulating Invisible Light: Adapting Lighting and Geometry Models for Radiant Heat Transfer. SimAUD 2020, 311–318.
12. Batista, G. (Author & Presenter), Dozier, A. (Author), Sharvelle, S. (Author), Arabi, M. (Author), Hydrology Days 2018, "Characterization of urban water use and water demand forecasting using the Integrated Urban Water Model in Sao Paulo, Brazil," Hydrology Days, Fort Collins, CO, United States. (March 19-21, 2018).
13. Batista, Giovana (Author & Presenter), Sharvelle, S. (Author), Dozier, A. (Author), Arabi, M. (Author), 9th International Congress on Environmental Modelling and Software, "Evaluation of Water Conservation Strategies Using the Integrated Urban Water Model in Sao Paulo, Brazil," International Congress on Environmental Modelling and Software, Fort Collins, CO, United States. (June 27, 2018).
14. Bell, Emily. "Conceptualization and Measurement of Stakeholder Beliefs in Urban Water Governance" at the UA School of Government and Public Policy Saguaro Symposium, February 2017
15. Bell, Emily, Adam Henry, and Gary Pivo. "Measuring Belief Systems in Urban Water Governance" at the Midwest Political Science Association, April 2017
16. Bell, Emily, Adam Henry, and Gary Pivo. "Measuring Beliefs through Coordination Networks in Urban Water Governance" at the Political Networks Conference, June 2017
17. Bell, E A Henry and G Pivo, November 2017. APPAM 39th Annual Fall Research Conference, A Coding Frame to Link Policies and Beliefs.
18. Berkowitz, Cherrier, Downey, and Meixner. 2019. Assessing Green Infrastructure Function Across North America with Citizen Scientists and Affordable Sensors. Urban Water Innovation Network Annual Meeting 2019. Fort Collins, CO.
19. Berkowitz, A., Cherrier, J., Downey, A. and Meixner, T. 2020 Rapid Assessment & Long-Term Monitoring of Urban Green Infrastructure with Citizen Scientists. Earthwatch Green Infrastructure Citizen Science Program. Zoom.
20. Berger, L, AD Henry and G Pivo (2019) Multiplexity of Government Action for Urban Water Sustainability, *Midwest Political Science Association Annual Conference*, April, 2019.
21. Berger, L, AD Henry and G Pivo (2019) Network Structure of Water Policy Innovations by Local Governments, *European Consortium for Political Research*, September 2019.

22. Berger, L, AD Henry and G Pivo (2020) Municipal Networks and Practices for Urban Water Sustainability, *Woman in Data Science Tucson*, April, 2020.
23. Bledsoe, B.P. (2017). *Probabilistic floodplain mapping as a template for planning urban revitalization*. 17th Annual American Ecological Engineering Society Meeting.
24. Bledsoe, B.P., 2018. The Three C's of Floodplain Management. Keynote Address, 12th Annual Meeting, Georgia Association of Floodplain Management, Athens, GA 20-22 Mar.
25. Bledsoe, B., & T. Stephens. 2018. *Mapping flood hazards under uncertainty through probabilistic flood inundation maps.* Presentation, Water Environment and Reuse Foundation (WERF), 2018 Water Research Foundation Conference, Atlanta, GA, May 6-8
26. Bledsoe, B. 2018. *Addressing flooding and extreme weather with restoration efforts.* Presentation, Southeast Stream Restoration Conference – EcoStream, Asheville, NC, August 14.
27. Bledsoe, B. 2018. *The three C's of flood management.* Presentation, Vanderbilt University, Nashville, TN, November 9.
28. Bledsoe, B. 2018. *Natural and nature-based infrastructure solutions.* Presentation, Atlantic Intracoastal Waterway Association (AIWA), 2018 Annual Meeting, Charleston, SC, November 16.
29. Bledsoe, B.P. and Stephens, T.A. Informing floodplain management and hazard communication through probabilistic flood inundation maps. Presented at the 2019 Georgia Water Resources Conference, Athens, Georgia, 16-17 April.
30. Bolson, J.A. M. Sukop, G. Pivo, M. Arabi, and A. Lanier (2018). *A stakeholder-science based approach for understanding urban water sustainability challenges across the U.S.* University of Florida Water Institute 2018 Symposium, February 6-7, Gainesville, Florida. http://archives.waterinstitute.ufl.edu/symposium2018/downloads/2018BookOfAbstracts.pdf
31. Bou-Zeid, E. (2016) "Cities in the 21st century: the nexus of the climate, water and energy challenges", University of Perugia.
32. Bou-Zeid, E. (2016) "Urban monitoring of air quality: the challenges of sampling in spatially and temporally varying fields", 2016 MIRTHE+ Symposium, City College of New York, NYC.
33. Bou-Zeid, E. (2016) "Missing pieces of the puzzle: the influence of dispersive fluxes and rainfall-induced quenching on surface-atmosphere exchanges in urban areas", Brookhaven National Lab.
34. Bou-Zeid E., Li Q., and Grimmond S. (2017) "Large Eddy Simulations of Flow and Scalar Exchanges over Urban Terrain to Improve Urban Canopy Model Parameterizations", 97th American Meteorological Society Annual Meeting, Seattle , WA
35. Bou-Zeid E., Omidvar H., Li Q., Klein P.M., Mellado J.P. (2018) "Plume or bubble? The non-linear impact of an urban heat island on city-scale atmospheric circulation" Invited. Fall meeting of the American Geophysical Union, Washington DC, https://agu.confex.com/agu/fm18/meetingapp.cgi/Paper/376481
36. Bou-Zeid E., Yang J. (2018) "The location and expanse of green and cool roofs strongly modify their cooling potential" Fall meeting of the American Geophysical Union, Washington DC, https://agu.confex.com/agu/fm18/meetingapp.cgi/Paper/412776
37. Bou-Zeid E. and Yang J. (2018) Hydrological Determinants of Temperature Extremes in Cities, 2018 Annual meeting of the American Meteorological Society, Austin, TX.
38. Bou-Zeid, E., and J. Yang, (2019) "Designing sensor networks to resolve spatio-temporal urban temperature variations: fixed, mobile or hybrid?". Fall meeting of the American Geophysical Union, San Francisco, CA.
39. Bou-Zeid, E., and M. L. Munitxa, (2019) "The environmental neighborhoods of cities and their spatial extent". Fall meeting of the American Geophysical Union, San Francisco, CA.
40. Borowy D, C Swann (2017). Identifying the processes that drive native plant community assembly patterns in urban habitats. Ecological Society of America 2017 Annual Conference.
41. Borowy D, C Swann (2017). Linking Community Assembly Processes in Experimental Urban Vacant Lot Habitats. Baltimore Ecosystem Study (BES) Annual Meeting.
42. Borowy D., Swan C.M. (2018). Annual Meeting of the Ecological Society of America, Oral Presentation, "Linking community assembly processes and patterns in experimental vacant lot habitats," Ecological Society of America, Portland, OR.
43. Borowy, D. (2018). Annual Meeting of the Baltimore Ecosystem Study, Oral Presentation, "Understanding biodiversity in the built environment," Baltimore Ecosystem Study (BES), Baltimore, MD.

44. Bozlar, M. ; Teitelbaum, E. ; Meggers, F. Liquid Desiccant-Polymeric Membrane Dehumidification System for Improved Cooling Efficiency. In International Building Physics Conference 2018; Syracuse, NY, 2018.
45. Brandi, Aldo, AM Broadbent, Matei Georgescu, Scott Krayenhoff (2020), Influence of Projected Climate Change, Urban Expansion and Adaptation Strategies on End of 21st Century Urban Boundary Layer Dynamics in the Conterminous US, 100th Meeting of the American Meteorological Society, January 16, 2020.
46. Brandi, A., Broadbent, A. M., Krayenhoff, E. S., & Georgescu, M. (2020, December). Influence of projected climate change, urban expansion and heat adaptation strategies on end of 21st century urban boundary layer across the Conterminous US. In AGU Fall Meeting 2020. (Poster - delivered remotely because of COVID-19 pandemic).
47. Broadbent, A. M., Krayenhoff, E. S., Georgescu M., and Sailor, D. J. Assessment of the biophysical impacts of utility-scale photovoltaics through observations and modelling. American Geophysical Union Fall Meeting, 11-15 December 2017, New Orleans, LA.
48. Broadbent, A. M., Krayenhoff, E. S., Georgescu M., and Sailor, D. J. Do photovoltaics impact local air temperature and surface energy balance? *Urban Climate Research Centre poster competition. March 2018.*Awarded* 1st Place in the Postdoctoral Researcher category
49. Broadbent, A. M., Krayenhoff, E. S., Heusinger, J., Georgescu, M (2019). Modeling the Direct Impacts of PV Systems on Surface Energy Balance and Climate in Phoenix. American Meteorological Society (AMS) conference, Phoenix, AZ 2019.
50. Broadbent, Ashley M., Matei Georgescu and E. Scott Krayenhoff (2020), Projecting End of Century Urban Population Exposure to Hot Extremes in the Continental US, 100th Meeting of the American Meteorological Society, January 16, 2020.
51. Brown, Alexander, Matthew Chiavatta, and Sarah Wrase. Michigan State University. A Spatial Analysis of Detroit Water Rates. April 9, 2018. University Undergraduate Research and Arts Forum UURAF.
52. Bruelisauer, M., Meggers, F., & Leibundgut, H. (2015). Heat Bus System to refurbish a high-rise residential building with semi-centralised high-performance chillers. In 6th International Building Physics Conference, IBPC 2015. Torino, Italy: Elsevier.
53. Burton, K., A. Maas, and Katherine Lee. 2021. "The Temporal and Spatial Extent of Home Value Losses Due to Chemical Spills". *UCOWR/NIWR Annual Water Resources Conference.* June.
54. Chan, E., Papuga, S.A., Eklund, A. 2019. Developing tools to assess the long-term and multifunctional performance of green infrastructure: A case study in Detroit, Michigan. AGU Fall Meeting, San Francisco CA, 9-13 December 2019. Poster presentation.
55. Chinnasamy, C. V., Dozier, A., Furth, C. D., and Arabi, M. (2019). Characteristics of water use across 125 urban centers in the contiguous USA: What did we learn? AGU Hydrology Days, March 27 - 29, 2019, Fort Collins, Colorado.
56. Chinnasamy, C. V., Dozier, A., Furth, C. D., Arabi, M., and Sharvelle, S. (2019). Characteristics of Municipal End Water Uses in the Contiguous USA. 16th Annual Rocky Mountain Student Conference, May 13, 2019, Boulder, Colorado.
57. Chinnasamy, C. V., Furth, C. D., Arabi, M., Sharvelle, S., and Dozier, A. (2019). Characteristics of Municipal End-Water Uses in the Contiguous USA. 4th Annual Meeting of the Urban Water Innovation Network, July 30 – August 1, 2019, Fort Collins, Colorado.
58. Davis, M.F. and M. Sarango (2019). "Water Affordability in Massachusetts Communities: Facts and Impacts." Presented to the Massachusetts Water Resources Authority Advisory Board, Wellesley, MA, November 21, 2019.
59. Davis, M.F. and M. Sarango (2020). "Water Affordability in Massachusetts Communities: Facts and Impacts." Presented to the Massachusetts Council on Aging, Watertown, MA, February 25, 2020
60. Davis, M.F., L. Senier, and S.L. Harlan (2020) The rising cost of household tap water: just sustainability in twelve Massachusetts communities. American Sociological Association Annual Meeting. Virtual (August).
61. Dell, T. (Author & Presenter), Arabi, M. (Author), 9th International Congress on Environmental Modelling and Software, "An introduction to the modeling framework and outputs of the Community-enabled Life-cycle Analysis of Stormwater Infrastructure Costs (CLASIC) tool," International Congress on Environmental Modelling and Software, Fort Collins, CO, United States. (June 25, 2018).

62. Dezfooli, D., Arabi, M., Bolson, J., Wiersema, I., Sukop, M. (2021). Understanding Urban Water Sustainability Transitions to One Water Using Science-based Expert Interviews. AGU Fall Meeting 2021. 13-17 December 2021. New Orleans, LA.
63. Dezfooli, D., Arabi, M., Wiersema, I., Bolson, J., Millonig, S., Reed, J., Sukop, M., Wamstad, K. (2022). An Introduction to Self-Assessment Framework for One Water Cities: A Roadmap to Support One Water Future and Guide Management Actions. 42nd Annual AGU Hydrology Days, 25-27 April, Colorado State University.
64. Dougherty, Benjamin. Water in the Global South and Narratives of Privatization: The Case of Brazil. Association of American Geographers (AAG) Conference. New Orleans, LA. April 9, 2018.
65. Dozier, A.Q. Wostoupal, B., Arabi, M. *Newcomers have subsidized water in the South Platte River Basin*. Hydrology Days at Colorado State University, Fort Collins, CO, Mar 19-21, 2018.
66. Dozier, A. (Author & Presenter), Arabi, M. (Author), 9th International Congress on Environmental Modelling and Software, "Optimizing water supply options for a region with urban-rural interactions," International Congress on Environmental Modelling and Software, Fort Collins, CO, United States. (June 26, 2018)
67. Dozier, A, M Arabi, and G Pivo (2018). Indicators for an Urban One Water approach. *International Congress on Environmental Modelling and Software*, Fort Collins, CO, United States. (June 2018).
68. Eddowes, D, J. Pillich, B. Smith, J. Cherrier, T. Meixner, A. Berkowitz and M. Chandler. 2019. Using citizen science and cross sector partnerships to engage new audiences in urban sustainability initiatives. Citizen Science Association Biannual Meeting. Raleigh, NC. March 16, 2019.
69. Emler, Lori- Hydrochemical evolution of nitrogen species in semi-arid urban catchments, Presentation at El Dia Del Agua y la Atmosfera, Department of Hydrology and Atmospheric Sciences, Tucson AZ, University of Arizona March 25, 2019.
70. Fabiani C., Posello A.L., Bou-Zeid E., and Yang J (2018) "Using advanced urban canopy models to investigate the potential of thermochromic materials as urban heat island mitigation strategies" International Building Physics Conference 2018, Syracuse, NY, USA: http://amz.xcdsystem.com/476EFEC7-D8CF-7470-232B140485F971CA_abstract_File1159/FinalPaperFileUpload_283_0627023621.pdf
71. Georgescu M. (2017), UWIN – A Multi-Institutional Partnership Focused on Sustainable Urban Water Systems, July 24, 2017 (Invited Speaker at Lee Kuan Yew School of Public Policy Seminar Series, National University of Singapore, Singapore).
72. Georgescu M. (2017), Urban Climate Research and Climate Change Challenges, August 21, 2017 (Invited Speaker at the Urban Climate Summer School, University of Bucharest, Romania)
73. Georgescu M. (2017), The utility of computational modeling to address urban environmental sustainability, August 22, 2017 (Invited Speaker at the Urban Climate Summer School, University of Bucharest, Romania).
74. Georgescu M (2019), Sustainable Urban Systems – A Climatic Perspective, Monday, December 16, 2019, The National Academies of Sciences, Engineering and Medicine, Washington D.C., USA (Invited Speaker for National Academies Workshop on Advancing Urban Sustainability in China and the United States - A National Academies Workshop in Collaboration with the Chinese Academy of Sciences).
75. Georgescu M (2019), A more holistic perspective on healthy and equitable urban environments – Beyond meteorology and climate, Wednesday, October 2, 2019, University of Tsukuba, Tsukuba, Japan (Invited Speaker for Center for Computational Sciences).
76. Georgescu M (2019), An urban climate perspective on human environment interactions, Tuesday, October 1, 2019, University of Tsukuba, Tsukuba, Japan (Invited Speaker for Tsukuba Global Science Week).
77. Georgescu M (2019), Quantifying human-urban interactions: an urban climate perspective, Webinar, Thursday, August 29, 2019 (Invited Speaker for Lawrence Berkeley National Laboratory/Pacific Northwest National Laboratory Monthly Webinar Series).
78. Georgescu M (2019), Sustainable Urban Systems: An Agri-Climatic Perspective, Qinghai Normal University, Qinhgai, China, Saturday, July 13, 2019 (Invited Speaker for the 7th Landscape Sustainability Science Forum).
79. Georgescu M (2020), Targeting Desired Outcomes: Do current thermal adaptation strategies miss the mark?, December 15, 2020, American Geophysical Union (Invited Talk for Extreme Weather and Climate

in Urban Areas and Their Social Impacts and Mitigation Session - delivered through Zoom because of COVID-19 pandemic).
80. Georgescu M (2020), The motley drivers of climatic change across US cities, December 3, 2020, Salt River Project (Invited Speaker for Salt River Project Utilities focused on enhancing research collaborations - delivered through Zoom because of COVID-19 pandemic).
81. Ghanbari, Mahshid and Mazdak Arabi, Current and Future Flood Losses in the Southeast Florida, EWRI World Environmental & Water Resource Congress 2017 24 May 2017.
82. Ghanbari, Mahshid , Mazdak Arabi, Jayantha Obeysekera, William V. Sweet, Risk to Assets and Communities from Coastal Flooding: Quantifying the effect of sea level rise and flood adaptation strategies, AGU Hydrology Days 2018 19 March 2018.
83. Ghanbari, Mahshid, Mazdak Arabi, Jayantha Obeysekera, William V. Sweet, Risk to Assets and Communities from Coastal Flooding: Quantifying the effect of sea level rise and flood adaptation strategies, International Congress on Environmental Modelling and Software 2018 24-28 June 2018.
84. Ghanbari, M., Arabi, M., Obeysekera, J., & Sweet, W (2018), Coastal Flooding Risks on the Rise, AGU Fall Meeting, Washington D.C. 10-14 December 2018.
85. Ghanbari, M., Arabi, M., Obeysekera, J., & Sweet, W (2019), A Coherent Statistical Model for Coastal Flood Frequency Analysis under Nonstationary Sea Level Conditions, AGU Hydrology Days, Fort Collins, Colorado. 27-29 March 2019.
86. Ghanbari, M., Arabi, M., Obeysekera, J., & Sweet, W (2019), A Coherent Statistical Model for Coastal Flood Frequency Analysis under Nonstationary Sea Level Conditions, EWRI World Environmental & Water Resource Congress, Pittsburgh, Pennsylvania. 20-23 May 2019.
87. Ghanbari, M., Arabi, M. Kao, S.-C. (2020). Increasing Risks of Compound Flooding under Climate Change and Sea Level Rise Scenarios. Hydrology Days 2020, April 13 – 15, Fort Collins, CO.
88. Ghanbari, M., Arabi, M. (2019). Impacts of Sea Level Rise on Compound Fluvial and Coastal Flooding. American Geophysical Union Fall Meeting 2019, December 9-13, San Francisco, CA.
89. Ghanbari, M. , Arabi, M., Kao, S., Obeysekera, J., and Sweet, W. Compound Coastal-Riverine Flooding Along the U.S. Coasts: The Effects of Sea Level Rise and River Flow Change. *AGU Hydrology Days*, March 30-31, 2021, Fort Collins, Colorado.
90. Ghanbari, M. (Author & Presenter), Arabi, M. (Author) " Modelling Compound Fluvial and Coastal Flooding Under Rising Sea Levels," International Environmental Modelling and Software Society, Brussels Belgium (online). (December 2, 2020).
91. Gharib, A., Arabi, M., Manning, D., Goemans, C. (2021) Changes in Water Delivery to Agricultural and Municipal Sectors Under Current Institutions in Response to Climate Change, Population Growth and Rapid Urbanization. Hydrology Days 2021, March 30-31, 2021, Fort Collins, CO.
92. Ghanbari, M., Arabi, M., Georgescu, M., Broadbent, A. M. (2021). Future Probability of Compound Hot-Dry Events Under the Impact of Climate Change, Urban Expansion, and Adaptation in US Cities. AGU Fall Meeting 2021. 13-17 December 2021. New Orleans, LA.
93. Ghanbari, M., Arabi, M., Kao, S. C., Obeysekera, J., & Sweet, W. (2021). Higher Probability of Compound Coastal-Riverine Flooding Under Climate Change Along the U.S. Coasts, EWRI World Environmental & Water Resource Congress, Virtual Online. June 7-11, 2021.
94. Ghanbari, M., Arabi, M., Kao, S. C., Obeysekera, J., & Sweet, W. (2021). Compound Coastal-Riverine Flooding Along the U.S. Coasts: The Effects of Sea Level Rise and River Flow Change, Hydrology Days 2021, Virtual Online. March 30-31, 2021.
95. Ghanbari, M., Arabi, M., Kao, S. C., Obeysekera, J., & Sweet, W. (2021). Assessment of Compound Coastal-Riverine Flooding Risks Under Climate Change along the U.S. Coasts. American Geophysical Union, Fall Meeting 2020, December 1-17, 2020. Virtual Online. https://doi.org/10.1002/essoar.10505413.1
96. Ghanbari, M., Arabi, M., Georgescu, M., Broadbent, A. M. (2022). Contemporary And Projected Probability of Compound Dry-hot Events Across U.S. Cities, EWRI World Environmental & Water Resource Congress, Atlanta. June 5-8, 2022.
97. Gharib, A., Arabi, M., Blumberg, J., Manning, D., Goemans, C. (2022) Can Investment in Storage Infrastructure Reduce Water Shortages? *Hydrology Days* 2022, April 25 – 27, 2022, Fort Collins, CO.

98. Gomez Fernandez, Edna-Liliana, Adam Henry (Co-Author), Gary Pivo (Co-Author), Andrew Sanderford (Co-Author), 2017. Association of Collegiate Schools of Planning Annual Conference, Measuring Fragmentation of Water Governance in US Cities: Theory and Evidence Examined.
99. Gomez Fernandez E. Liliana, A. Henry, and G. Pivo, August, 2017. UWIN 2nd Annual Meeting, Influence of Governmental Fragmentation in Adoption of Sustainable Policies and Innovation in Urban Water Management
100. Gomez Fernandez, Edna Liliana. "Water Sustainability Innovations through Collaborative Networks." Paper presented at Southern Political Science Association (SPSA) Annual Conference, Austin, Texas, January 2019.
101. Gomez Fernandez, Edna Liliana, Adam Douglas Henry & Gary Pivo. "Collaborative Governance in Urban Water Management in Arizona: Belief Systems, Perceptions, and Common Problems." Presented at Consortium on Collaborative Governance (CCG) Emerging Scholars Workshop, Tucson, Arizona, February 2019.
102. Gomez Fernandez, Edna Liliana Adam Douglas Henry, and Gary Pivo (2019). "Collaboration in Urban Water Management in Arizona." Political Networks Conference (Polnet). Duke University, June, 2019.
103. Greydanus, H. and M. Santelmann. 2018. Quantifying the cooling benefits of green infrastructure on air temperatures in Portland, Oregon. Abstract accepted for Ecological Society of America meeting, New Orleans, LA. August 2018.
104. Greydanus, H, Santelmann M. 2018. Ecological Society of America Annual Conference (Poster), Influence of urban green infrastructure on air temperature variability in Portland, Oregon August 2018, New Orleans, LA
105. Greydanus H., Santelmann M. 2018. Microclimate cooling of green infrastructures in Portland, Oregon. Collegiate Poster & Rapid Fire Competition. Society of Women Engineers, October 18-20 2018. Minneapolis, MN.
106. Guo, H., & Meggers, F. (2018, September 23). Analytical and Numerical Investigation on Depth and Pipe Configuration for Coaxial Borehole Heat Exchanger, A Preliminary Study. In International Building Physics Conference 2018; Syracuse, NY, 2018.
107. Guertin, D. Phillip, Yoganand Korgaonkar, I. Shea Burns, Carl Unkrich, David C. Goodrich, and William Kepner. 2016. Using AGWA and the KINEROS2 Model to Model Green Infrastructure in Two Typical Residential Lots in Prescott, AZ. Presented at: 2016 AWRA Summer Specialty Conference: GIS and Water Resources IX, Sacramento, CA, July 11-13, 2016.
108. Gupta, Neha - Comparison of Runoff Data to Assess Impact of Stormwater Green Infrastructure, Presentation at El Dia Del Agua y la Atmosfera, Department of Hydrology and Atmospheric Sciences, Tucson AZ, University of Arizona April 9,2018.
109. Gupta, Neha, and Emily Bell, 2017, Interdisciplinary dialogue to assess coupled natural and human systems, El Dia Del Agua Y Atmosfera, University of Arizona, Tucson, AZ March 27, 2017.
110. Gupta, N. and E. Bell (2017). Interdisciplinary Dialogue to Assess Green Stormwater Infrastructure (poster). El Día del Agua y la Atmósfera, March 2017.
111. Gupta, N., Solis-Arroyo, S.S., Meixner, T., Anderson, J. and Gallo, E.L., 2018, December. Comparative Assessment of Water Quality at the Rainwater-Harvesting Basin and Neighborhood Wash Scales. In AGU Fall Meeting Abstracts.
112. Gupta, N., Meixner, T., Gallo, E.L., Canfield, E. and Spinti, R., 2018, December. Runoff increases due to urbanization in a semi-arid city. In AGU Fall Meeting Abstracts.
113. Gupta, Neha— Quantification of Runoff Response in Semi-Arid Urban Catchment – Arizona Hydrological Society Annual Symposium, Phoenix AZ, September 20, 2018.
114. Gupta, Neha - Runoff increases due to urbanization in a semi-arid city, Presentation at El Dia Del Agua y la Atmosfera, Department of Hydrology and Atmospheric Sciences, Tucson AZ, University of Arizona March 25, 2019.
115. Gupta, Neha, Stormwater Runoff Response in Semi-Arid Urban Catchment, AWWA Sustainable Water Management Conference, Tucson, AZ, April, 2019.
116. Habron G., Thompson K., Maas A., Berkowitz A. 2019. Experiential model-based reasoning for undergraduate interdisciplinary urban water synthesis. American Association of Geographers Annual Meeting, April 3rd-7th, Washington DC. Oral presentation

117. Haggerty, R., Hulse, D., Conklin, D., Santelmann, M., Wright, M. (2016). Project D1-1: UWIN Envision Modeling of Present and Future Values for Sustainable Water Management Blueprint Indicators. Urban Water Innovations Network, Annual Meeting, Ft. Collins, Colorado. August 2-4, 2016.
118. Harlan, S. L. Social Equity, Environmental Justice, and Societal Ethics Panel. Presented at the Sustainability Research Network Awardees Conference, National Science Foundation. Alexandria, VA. June 5-6, 2018.
119. Harlan, S, P Chakalian, J Declet-Barreto, D Hondula, GD Jenerette (2019). Climate Injustice in Cities: Extreme Heat and Poor Neighborhoods. American Geophysical Union. San Francisco CA December 2019
120. Harlan, S.L.,(2020) "Social Vulnerability and Perceived Risk of Floods." Invited presentation at the American Meteorological Society Annual Meeting, Boston, MA, January 12-16, 2020
121. Harlan, S.L. and L. Senier. "Water Unaffordability and Community Assistance Plans in Selected Cities. MIT Water Affordability Workshop, May 23-24, 2022.
122. Harrison, M., Santelmann, M., Haggerty, R. 2017. Historical Evaluation of Groundwater Responses to Underground Injection Controls in an Urban Watershed. Poster presentation American Geophysical Union Fall Meeting, New Orleans, LA. December 2017
123. Heidari, H., Arabi, M., Warziniack, T., Kao, S.-C. (2020). Assessing the Impacts of Climate Changes on the Regional Hydroclimatic Conditions of U.S River Basin over the 21st Century. Hydrology Days 2020, April 13 – 15. Fort Collins, CO.
124. Heidari, H., Arabi, M., Warziniack, T., Kao, S.-C. (2019). Changes in Hydroclimatic Characteristics of River Basins in the U.S. over the 21st Century. AGU Fall Meeting, Dec 9 – 13, San Francisco, CA.
125. Heidari, H., Arabi, M., Ghanbari, M., Warziniack, T. (2019). A Mixture Gamma-GPD Probability Model for Characterization of Water Shortage Vulnerability under Nonstationary Supply and Demand Conditions. World Environmental and water resources congress, May 19 – 23. Pittsburgh, PA.
126. Heidari, Hadi, Mazdak Arabi, Andre Dozier, Ali Tasdighi, An Analytical Framework for Assessing Municipal Vulnerability to Water Shortage and Drought Characteristics under Nonstationary Supply and Demand Conditions, AGU Hydrology Days 19 March 2018
127. Heidari, Hadi, Mazdak Arabi, Andre Dozier, Ali Tasdighi, An Analytical Framework for Assessing Water Shortage Vulnerability under Nonstationary Supply and Demand Conditions, 9th International Congress on Environmental Modelling and Software 2018 24-28 June 2018
128. Heidari, Hadi, Mazdak Arabi, Mahshid Ghanbari, A Novel Probabilistic Approach for Characterization of Municipal Water Shortage Vulnerability under Nonstationary Supply and Demand Conditions. *AGU Fall Meeting, Washington, D.C.*, December. 2018
129. Heidari, Hadi, Mazdak Arabi, Mahshid Ghanbari, Travis Warziniack, Vulnerability of the City of Fort Collins Water Supply System to Water Shortage and Extended Droughts under Nonstationary Supply and Demand Conditions over the Course of the 21st Century. *AGU Hydrology Days,* Fort Collins, March. 2019
130. Heidari, Hadi, Mazdak Arabi, Mahshid Ghanbari, Travis Warziniack, A Mixture Gamma-GPD Probability Model for Characterization of Water Shortage Vulnerability under Nonstationary Supply and Demand Conditions. *World Environmental and water resources congress,* Pittsburgh, May. 2019
131. Heiden, C. (Author & Presenter), Arabi, M. (Author), 2018 AGU Fall Meeting, "A novel probabilistic approach to characterization of water quality vulnerability along Urban Gradients," American Geophysical Union, Washington, D.C., (December 10, 2018).
132. Henry, Adam, E.L. Gomez-Fernandez, and G. Pivo, March, 2017. The International Association for the Studies of the Commons. Workshop: Multi-methods Approaches for Investigating Polycentricity in Common Pool Resources.
133. Henry, A EL Gomez-Fernandez and G Pivo, November 2017. APPAM 39th Annual Fall Research Conference, A Network Approach to Understanding Fragmentation and Sustainability in Local Governance.
134. Henry, AD, EL Gomez-Fernandez and G Pivo (2018). Network-Based Measurement of Functional Fragmentation in Governance Systems: An Application to Urban Water Management, *Association for Public Policy Analysis and Management*, February 2018.
135. Henry, Adam Douglas, Lena Berger, Gary Pivo, Edna Liliana Gomez Fernandez. "Network drivers of local water sustainability innovations." Presented at 2018 Public Management Research Conference (PMRC), Singapore, June 2018.

136. Henry, Adam Douglas, Edna Liliana Gómez Fernández & Gary Pivo. "Sustainability Innovations through Collaboration in Urban Water Management." Paper presented at Association for Public Policy Analysis and Management (APPAM) Fall Research Conference, Washington, D.C., November 2018.
137. Henry, Adam Douglas, Lena Berger, Edna Liliana Gomez Fernandez & Gary Pivo. "What distinguishes local government innovators in water sustainability?" Climate Change Adaptation Science & Solutions Speaker Series, Tucson, Arizona, March 2019.
138. Henry, Adam Douglas, Edna Liliana Gomez Fernandez and Gary Pivo (2019). "Water Policy Innovations through Collaborative Governance Networks." Association for Public Policy Analysis and Management (APPAM) 41st Annual Fall Research Conference, University of Arizona, November 2019.
139. Hermosilla, Victoria — Rainwater Harvesting Infiltration Exploration Using Hydrus-1D, 2018 – Arizona Hydrological Society Annual Symposium, Phoenix AZ, September 20, 2018.
140. Guardaro M, Hondula DM, Messerschmidt M, Grimm N, Redman C (Jan. 2020). Building community heat action plans story by story: A three neighborhood case study. Poster presentation, American Meteorological Society Annual Meeting, Boston, Massachusetts, USA.
141. Hondula DM, Urban A (Aug. 2018). Detecting an urban effect in heat-related mortality records in Maricopa County, AZ. International Conference on Urban Climate, New York City, New York, USA.
142. Hondula DM, Putnam H, Urban A, Iniguez P, Berisha V, Roach M (Jan. 2018). Record-setting heat and heat-related deaths in Maricopa County in 2016: cause and effect? American Meteorological Society Annual Meeting, Austin, Texas, USA.
143. Horvath, A., Gursel, A. P., Chaudron, C. and Kavvada, I. (2020), "An Integrated Model of Urban Water-Wastewater-Stormwater-Energy Systems." EGU General Assembly 2020, May 4-8, 2020, Vienna (Austria)
144. Ibsen P and GD Jenerette. Effects of extreme climate on suites of functional traits in the urban forest of Southern California. Ecological Society of America, Portland, OR August 2017
145. Ibsen P, M Talal, C Swan, D Borowy, D Hondula, M Wright, and GD Jenerette. Continental scale variation in the cooling effect of urban vegetation. United States Chapter of the International Association of Landscape Ecologists. Chicago IL April 2018
146. Ibsen P, GD Jenerette, MV Santelmann, H Greydanus, D Hondula, M Wright, C Swan, D Borowy, M Sukop, T Dell, T Meixner. Regional aridity drives urban nighttime vegetation derived air cooling. American Geophysical Union. Washington DC December 2018
147. Ibsen P, GD Jenerette, LS Santiago, M Chandler, SA Shiflett (2019). Irrigated Urban Forests Shift to Anisohydric Strategies in Extreme Aridity. American Geophysical Union. San Francisco CA December 2019
148. Jenerette GD. A macroecology of urban trees. Ecological Society of America, Portland, OR August 2017.
149. Jenerette GD, J Wang, M Chandler, J Ripplinger, S Koutzoukis, C Ge, L Castro-Garcia, D Kucera, X Liu. Resolving uncertainties in the urban air quality, climate, and vegetation nexus through citizen science, satellite imagery, and atmospheric modeling. American Geophysical Union, New Orleans LA December 2017
150. Jenerette GD. Experimental landscape ecology. United States Chapter of the International Association of Landscape Ecologists. Chicago IL April 2018
151. Jenerette GD. Opportunities for urban ecology at the United States and Mexico border. Ecological Society of America Annual Meeting. New Orleans August 2018
152. Jenerette, GD (2019) From wildland urban interfaces to anthropogenic landscape systems in southern California, USA. United States Chapter of the International Association of Landscape Ecologists. Fort Collins CO April 2019
153. Jenerette GD, P Ibsen, D Kucera, S Harlan, M Georgescu (2019). A continental assessment of the urban vegetation, temperature, income nexus. American Geophysical Union. San Francisco CA December 2019
154. Johnson, A. (Author & Presenter), Swan, C. M. (Author), Annual Meeting of the Ecological Society of America, Oral Presentation, "The independent and interactive effects of plant functional and phylogenetic diversity on urban ecosystem services," Ecological Society of America, Portland, OR, (2017).
155. Joseph George, A., Arabi, M., Sharvelle, S., and Dell, T. (2019). Assess Performance of Urban Stormwater Control Measures (SCMs) under varying Maintenance Regimes. 39th Annual AGU Hydrology Days, March 27 -29, 2019, Fort Collins, CO.
156. Joseph George, A., Dell, T., and Sharvelle, S. (2018). Evaluating Uncertainty in Stormwater Control Measures (SCMs) using the EPA Storm Water Management Model linked with Markov Chain Monte-Carlo

Uncertainty Technique. 9th International Congress on Environmental Modelling and Software, Modelling for Sustainable Food-Energy-Water Systems, June 24 - 28, 2018, Fort Collins, CO.
157. Keeley-LeClaire, T., Teitelbaum, E., Shim, S., Bozlar, M., Stone, H. A., & Meggers, F. (2018, September 23). Extracting Radiant Cooling From Building Exhaust Air Using the Maisotsenko Cycle Principle. 6. In International Building Physics Conference 2018; Syracuse, NY.
158. Kim, J.S. (Author & Presenter), Arabi, M. (Author), 9th International Congress on Environmental Modelling and Software, "Development of Watershed Delineation Tool Using Open Source Software Technologies," International Congress on Environmental Modelling and Software, Fort Collins, CO, United States. (June 27, 2018).
159. Kirby, T. L., A. Henry, J. Bolson, M. Sukop (2018) Regional Climate Change Adaptation Policy Network in Southeast Florida, Abstract PA11D-0818 presented at 2018 AGU Fall Meeting, Washington, D.C., 10-14 Dec. https://doi.org/10.1002/essoar.10500841.1
160. Korgaonkar, Y., Guertin, D. P., Goodrich, D. C., Unkrich, C., Kepner, W, and Burns, I. S. (2018). Modeling Urban Hydrology and Green Infrastructure using the AGWA Urban Tool and the KINEROS2 Model. In: Proceedings of the Sixth Interagency Conference on Research in the Watersheds, Shepherdstown, WV.
161. Koutzoukis S, Andrews H, S Crum, GD Jenerette. Dynamic microclimate effects of vegetation throughout a 1600 m elevation transect in Southern California, USA. Ecological Society of America, Portland, OR August 2017.
162. Koutzoukis S, GD Jenerette, M Chandler, J Wang, C Ge, and J Ripplinger. Regional and local meteorology influences high-resolution tropospheric ozone concentration in the Los Angeles Basin. American Geophysical Union, New Orleans LA December 2017
163. Krayenhoff, E.S., Georgescu, M., and M. Moustaoui. Built Expansion and Global Climate Change Drive Projected Urban Heat: Relative Magnitudes, Interactions, and Mitigation. Session: Urban Areas and Global Change, AGU Fall Meeting, 12-16 December 2016, San Francisco.
164. Krayenhoff, E.S., Georgescu, M., and M. Moustaoui. Global Climate Change and Urban Development as Drivers of Urban Heat: Relative Magnitude, Interactions, and Mitigation. Joint Session: Intersections of Global Climate Change and Urbanization, AMS 13th Symposium on the Urban Environment, 22-26 January 2017, Seattle.
165. Krayenhoff, E.S., A. Broadbent, M. Georgescu, E. Erell, A. Martilli, A. Middel, D. Sailor. 2017. Urban cooling from heat mitigation strategies: Systematic review of the numerical modeling literature. Urban Climate News, Issue 64, International Association for Urban Climate, p. 22-25.
166. Krayenhoff, E.S., Georgescu, M., and M. Moustaoui. Climates of U.S. cities in the 21st century. Annual meeting of the Urban Water Innovation Network (National Science Foundation), 31 Jul – 2 Aug 2017, Fort Collins, CO (poster).
167. Krayenhoff, E.S. Street-level climate and dispersion in mesoscale models. Urban Meteorology and Land Surface Processes (session), Meteorology and Climate – Modeling for Air Quality Conference, UC Davis, 13-15 September 2017 (Invited Paper).
168. Krayenhoff, E.S., Georgescu, M., and M. Moustaoui. Climates of U.S. cities in the 21st century. Urban Areas and Global Change (session), American Geophysical Union Fall Meeting, 11-15 December 2017, New Orleans, LA (Invited Paper).
169. Krayenhoff, S., A.M. Broadbent, E. Erell, L. Zhao, M. Georgescu, J.A. Voogt, A. Middel, A. Martilli, D. Sailor. Urban cooling from heat mitigation strategies: Systematic review of the numerical modeling literature. Tenth International Conference on Urban Climate, 6-10 August 2018, New York, USA.
170. Kucera DC and GD Jenerette. Decadal resistance and resilience of the Los Angeles urban forest in response to drought and temperature stress. Ecological Society of America, Portland, OR August 2017
171. Kucera D and GD Jenerette (2019). The Response of Whole-City Urban Vegetation to Severe Drought in Los Angeles, CA, USA. American Geophysical Union. San Francisco CA December 2019
172. Kunnie, Mandla- Development of a database of Tucson Green Infrastructure sites, Presentation at El Dia Del Agua y la Atmosfera, Department of Hydrology and Atmospheric Sciences, Tucson AZ, University of Arizona March 25, 2019.
173. Kunnie, Mandla, Creation of Tucson GIS Green Infrastructure Database, AWWA Sustainable Water Management Conference, Tucson, AZ, April, 2019.
174. Lammers, R.W., Dell T., and Bledsoe, B.P. 2020. Integrating stormwater management and stream

restoration strategies for greater water quality benefits. Poster presented at the SUSE5: The Symposium on Urbanization and Stream Ecology, Austin, TX, 12-15 Feb.
175. Lammers, R.W., Dell T., and Bledsoe, B.P. 2019. Uniting stormwater management and stream restoration strategies for greater water quality benefits. Presented at the 19th Annual Meeting of the American Ecological Engineering Society Conference: "Enabling Future Generations to Solve Our Planet's Grand Challenges", Asheville, North Carolina, 3-6 June.
176. Lammers R.W., Dell T., and Bledsoe B.P. 2019. Uniting stormwater management and stream restoration strategies for greater water quality benefits. Presented at the 2019 Georgia Water Resources Conference, Athens, Georgia, 16-17 April.
177. Lee, G., and A.J. Miller, 2017. Monitoring Urban Stream Restoration Efforts in Relation to Flood Behavior Along Minebank Run, Towson, MD. Abstract H31L-1629, Fall 2017 Annual Meeting, AGU, New Orleans, LA, 11-15 Dec.
178. Lee, G. and A.J Miller, 2018. *Using SfM in creating high resolution DEMs for tracking changes in channel bed morphology and hydraulic modeling.* Abstract H43J-2614. AGU Fall Meeting 2018.
179. Lee, G. and Miller, A. 2019. Examining the Effect of Changing Floodplain/Channel Morphology on Flood Hydraulics at Minebank Run, Baltimore County, MD. Poster (H53L-1940), 2019 AGU Fall Meeting, San Francisco, CA, December 9-13.
180. Li, Q. And Bou-Zeid E. (2016), Developing Urban Surface Parameterizations for Momentum and Scalars Using Large-Eddy Simulations, 22nd Symposium on Boundary Layers and Turbulence, Salt Lake City, Utah.
181. Li, Q. And Bou-Zeid E. (2016), Contrasts Between Momentum and Scalar Exchanges Over Very Rough Surfaces, Bulletin of the American Physical Society, 61.
182. Li Q., Bou-Zeid E., and Grimmond S. (2017) "On the Momentum and Scalar Roughness Lengths of Urban Surfaces", 97th American Meteorological Society Annual Meeting, Seattle , WA.
183. Li Q., Bou-Zeid E., Yang J., Wang Z.-H. (2018) "Improving the representation of convective heat transfer in an urban canopy model", International Building Physics Conference 2018, Syracuse, NY, USA: http://amz.xcdsystem.com/476EFEC7-D8CF-7470-232B140485F971CA_abstract_File1159/FinalPaperFileUpload_424_0612122558.pdf
184. Li, Q., E. Bou-Zeid, G. G. Katul, S. B. Grimmond, and S. Zilitinkevich, 2019: "Linking Momentum and Scalar Roughness Lengths of Urban Surfaces at the Macro and Micro-scales." Fall meeting of the American Geophysical Union, San Francisco, CA.
185. Lim, T.C. and Welty, C. (2018) Spatial Considerations of Distributed Green Stormwater Infrastructure Implementation, Fall meeting of the American Geophysical Union, Washington DC, https://agu.confex.com/agu/fm18/meetingapp.cgi/Paper/424197
186. Llaguno Munitxa M., Bou-Zeid E., Bogosian B., Al Tair A., Radcliff D., Fisher S., Ryu Y. (2018) "Sensing and information technologies for the environment (SITE); hardware and software innovations in mobile sensing applications", International Building Physics Conference 2018, Syracuse, NY, USA: http://amz.xcdsystem.com/476EFEC7-D8CF-7470-232B140485F971CA_abstract_File1159/FinalPaperFileUpload_430_0630060005.pdf
187. Llaguno-Munitxa M., B. Bogosian, E. Bou-Zeid, A. Al Tair, D. Radcliff, Z. Chen, S. Fischer, Y. Ryu, J. Kim, and J. Bae (2018) Blending Hardware and Software Innovations in Mobile Urban Sensing Technologies, 2018 Annual meeting of the American Meteorological Society, Austin, TX.
188. Llaguno-Munitxa, M. and Bou-Zeid, E. (2020) "Opportunistic Mobile Urban Sensing Technologies". Annual meeting of the American Meteorological Society, Boston, MA
189. Lochet A., Berkowitz A., Vincent S., Habron G., Maas A., Gosselin D. 2018. Building transdisciplinary skills among undergraduate students through summer research experiences. Council on Undergraduate Research Biennial Conference, July 1st-3rd 2018, Arlington VA. Poster presentation.
190. Maas, Alexander (2018) Complements of the house: Estimating demand-side linkages between residential water and electricity. Western Agricultural Economics Annual Meeting. Anchorage, AK. June 24-26, 2018
191. Maas, Alexander (2018). Eliciting Preferences through Discrete Choice Experiments. Palouse Basin Aquifer Committee, Moscow, ID. October 24, 2018
192. Maas, Alexander (2019) Complements of the house: Estimating demand-side linkages between residential water and electricity. Hydrology Days, Fort Collins, CO. March 27-29, 2019
193. Maas, Alexandner (2019). Other-regarding Behavior when Common Pool Resources Have Tipping Points.

Presented at Western Agricultural Economics Association annual meeting. Coeur d'Alene ID, June 2019
194. Maas, A & Koroles Awad (2019). Preferences for Alternative Water Supplies in the Pacific Northwest: A Choice Experiment. Presented at Palouse Basin Water Summit annual meeting. Pullman WA, October 2019
195. Mack, E.A. (2017) A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States. Association of American Geographers (AAG) Conference. Boston.
196. Mack, Elizabeth. Human Dimensions of the Urban Water Innovation Network (U-WIN). Earth and Environmental Sciences Seminar Series, Wayne State University Colloquium. March 7, 2018.
197. Mack, E.A. An Input-Output Framework for Analyzing Consumer Responses to Changing Water Prices. North American Regional Science Association Conference. San Antonio, TX. November 7-10, 2018
198. Mack, E.A. "A Geographic Assessment of Water and Sewer Service Affordability in the Detroit Metropolitan Area." Association of American Geographers, Washington, D.C. April 4, 2019
199. Mack, E.A. Household Expenditure Change and Cascading Effects as a Result of Increasing Costs of Water Services. North American Regional Science Conference. Pittsburgh, PA November 13-16, 2019
200. Mack, E.A. Water Rates in Detroit. Global Water Justice Summit: The Michigan Conference. Detroit Michigan. January 24-25 2020
201. Mariluz, L., J. Divalli, S.L. Harlan, L. Senier. "Collaboration between Community-Based Environmental Orgianizations and Water Resource Management Agencies: A Challenge for Achieving Water Justice." Poster presentation at the Research, Innovation, and Scholarship Exposition (RISE), Northeastern University, April 4, 2019.
202. McWest L., Broadbent, A., Vanos, J., Georgescu, M., Middel, A. 2019. Impacts of urban tree canopy and water features on the thermal environment. American Meteorological Society 99th Annual Meeting, January 6-10 2019. Phoenix, AZ. Poster presentation.
203. Medwid, Laura. Perceptions of Water Affordability. North American Regional Science Conference. Pittsburgh, PA November 13-16, 2019.
204. Meggers, Forrest, Hongshan Guo, Eric Teitelbaum, Gideon Aschwanden, Jake Read, Nicholas Houchois, Jovan Pantelic, and Emanuele Calabrò. 2017. "The Thermoheliodome – 'Air Conditioning' without Conditioning the Air, Using Radiant Cooling and Indirect Evaporation." Energy and Buildings, June. https://doi.org/10.1016/j.enbuild.2017.06.033.
205. Meggers, Forest (2019). Radiant sensing, ASHRAE 2019 summer meeting, Kansas City, MO
206. Meggers, Forest (2019). Outdoor radiant cooling, ASHRAE 2019 summer meeting, Kansas City, MO
207. Meggers, Forest (2020). Thermal Resilience, Regenerating Good, National Thai Design Week, Feb 2020, Bangkok Thailand
208. Meggers, Forrest and Dorit Aviv (2021). ASHRAE Philadelphia Chapter Meeting. CHAOS (Cooling And Heating For Architecturally Optimized Systems). Feb 18, 2021 https://ashraephilly.org/meetinginfo.php?id=132
209. Meggers, Forrest (2020). "Resilient Radiant Cooling" at the "Resilient Cooling" workshop of the Indoor Air Conference 2020, Nov 1, 2020. Online
210. Meixner, T. 2016, Green Infrastructure as a Puzzle Piece for Water Resources in the Southwest, Presented at – Fourth Annual Kent State University Water and Land Symposium, Kent Ohio, October 6, 2016.
211. Meixner, T., Papuga, S.A., Luketich, A.M., Rockhill, T., Gallo, E.L., Anderson, J., Salgado, L., Pope, K., Gupta, N., Korgaonkar, Y. and Guertin, D.P., 2017, December. Green Infrastructure Increases Biogeochemical Responsiveness, Vegetation Growth and Decreases Runoff in a Semi-Arid City, Tucson, AZ, USA. In AGU Fall Meeting Abstracts.
212. Meixner, Thomas— Green Stormwater Infrastructure Increases Infiltration, Soil Carbon and Biogeochemical Response, 2018 – Arizona Hydrological Society Annual Symposium, Flagstaff AZ, September 7, 2018.
213. Meixner, Thomas, Green Stormwater Infrastructure Function and Interactions with Maintenance, AWWA Sustainable Water Management Conference, Tucson, AZ, April, 2019.
214. Meltzer S., Georgescu, M, Broadbent, A., Vanos, J., Middel, A. 2019. Impacts of trees on urban canyon microclimate. American Meteorological Society 99th Annual Meeting, January 6-10 2019. Phoenix, AZ. Poster presentation.

215. Miller, A.J., G. Lee, B.P. Bledsoe, and T. Stephens, 2017. Mitigation of Flood Hazards Through Modification of Urban Channels And Floodplains. Abstract H31L-1630, Fall 2017 Annual Meeting, AGU, New Orleans, LA, 11-15 Dec.
216. Miller, A.J., 2018. *Extreme floods in the Baltimore Metropolitan Region or The Myth of the 1000-Year Flood*. Wolman Club Annual Meeting, UMBC, Baltimore, MD., 1 June.
217. Miller, A.J., 2018. *Extreme floods in Ellicott City and the Baltimore Metropolitan Region*. Maryland Department of Transportation Geohazards Forum Field Trip, Keynote Speaker, Ellicott Mills Brewing Company, Ellicott City, MD., 7 August.
218. Miller, A.J., 2018. *What do we know about extreme floods in Ellicott City and the Baltimore Metropolitan Region?* Ellicott City Flash Flood Symposium, UMBC, Baltimore, MD. 7 Sept.
219. Miller, A.J., 2018. *What do we know about extreme floods in Ellicott City and the Baltimore Metropolitan Region?* Baltimore Ecosystem Study 20th Annual Meeting, University of Baltimore, Baltimore, MD., 25-26 Oct.
220. Miller, A.J., J.A. Smith, M.J. Cashman, J.J.A. Dillow, E.J Doheny, M.L. Baeck, M.M. Chaney, 2018. *Extreme floods in the Baltimore metropolitan region and the myth of the 1000-year flood.* Abstract H53F-03, Fall 2018 Annual Meeting, AGU, Washington, D.C., 10-14 Dec.
221. Miller, A.J., J.A. Smith, M.L. Baeck, M.M. Chaney, E. Claggett, and T.S. Shah, 2020. Fall Meeting of the American Geophysical Union, Poster. What do small urban watersheds tell us about climate change? Coupled analyses of two decades of urban streamflow and a 20-year high-resolution radar rainfall data set.
222. Mohammad-Zadeh, M., Arabi, M., Sharvelle, S., Dell, T. Assessing the Performance Validity of the CLASIC Tool for the Characterization of Urban Hydrologic Components Compared to a Full SWMM Model. AGU Hydrology Days, March 30-31, 2021, Fort Collins, CO.
223. Moradnejad, Maryam, Dorit Aviv, Aletheia Ida, and Forrest Meggers. 2019. "WATeRVASE: Wind-Catching Adaptive Technology for a Roof-Integrated Ventilation Aperture System and Evaporative-Cooling." Building Technology Educator's Society 2019 (1). https://doi.org/10.7275/px8f-ah94.
224. Neale, M., A. Dozier, S. Sharvelle, M. Arabi (2018) Identifying Optimal Water Conservation and Reuse Strategies Using and Urban Water Demand Model for a Selection of US Cities with Distinct Climatic Conditions and Land Cover Characteristics, Hydrology Days, Fort Collins, CO.
225. Neale, M., Sharvelle, S., Dozier, A., Arabi, M. (2018) "Identifying Optimal Water Conservation and Reuse Strategies Using an Urban Water Demand Model for a Selection of U.S. Cities with Distinct Climatic Conditions and Land Cover Characteristics," 9th International Congress on Environmental Modelling and Software Fort Collins, CO.
226. Neale, M., Sharvelle, S., Arabi, M. (2019) "Cost-benefit evaluation of water conservation and reuse strategies using the Integrated Urban Water Model for three U.S. cities", Hydrology Days, Fort Collins, CO.
227. Omidvar H., Bou-Zeid E., Song J., Yang J., Arwatz G., Byers C., Wang Z., Hultmark M., and Kaloush K. (2017) "Rapid Modification of Land Surface Temperature during Rainfall", 97th American Meteorological Society Annual Meeting, Seattle , WA.
228. Omidvar, H and Bou-Zeid, E and Song, J and Yang, J and Arwatz, G and Wang, Z and Hultmark, M and Kaloush, K (2017) Rapid modification of urban land surface temperature during rainfall, AGU Fall Meeting, New Orleans, LA.
229. Omidvar H. And Bou-Zeid E. (2018) "Rapid cooling of urban surfaces during rainfall: physical basis, dominant energy fluxes, and sensitivity to pavement and rainfall properties" International Building Physics Conference 2018, Syracuse, NY, USA: http://amz.xcdsystem.com/476EFEC7-D8CF-7470-232B140485F971CA_abstract_File1159/FinalPaperFileUpload_400_0628030315.pdf
230. Omidvar H., Bou-Zeid E., Li Q., Mellado J. P., Klein P. (2018). A study of city--scale atmospheric circulations, and their transition from plume to bubble. American Physical Society Division of Fluid Dynamics Meeting. Atlanta, GA, Bulletin of the American Physical Society. https://meetings.aps.org/Meeting/DFD18/Session/D34.6
231. Pantelic, J. E Teitelbaum, M Bozlar, S Kim, F Meggers, Development of moisture absorber based on hydrophilic nonporous membrane mass exchanger and alkoxylated siloxane liquid desiccant, Energy and Buildings 160, 34-43

232. Patterson, D. (Author & Presenter), Arabi, M. (Author & Presenter), Traff, K. (Author), 9th International Congress on Environmental Modelling and Software, "Workshop: eRAMS Online Tools for Integrated Resource Management," International Congress on Environmental Modelling and Software, Fort Collins, CO, United States. (June 27, 2018).
233. Pivo, G. (2018). Innovations in Responsible Property Investing. *Real Estate Consulting Group of America (RECGA)*, April, 2018.
234. Poost, M. S. (Author & Presenter), Johnson, A. (Author), Swan, C. M. (Author), Ashman, T.-L. (Author), Annual Meeting of the Ecological Society of America, Poster, "Pollination in the city: Restored native species interact with spontaneous urban weeds via pollen transfer in vacant lots," Ecological Society of America, Portland, OR, (2017).
235. Puri, R., & Maas, A. (2019) Evaluating the sensitivity of residential water demand estimation to model specification and instrument choices. Presented at Universities Council of Water Resources. Snowbird UT, June 2019
236. Redican, K and E.A. Mack (2017). The Socio-Economic Impacts of Rising Water Prices using Scenario Based Modeling. Association of American Geographers (AAG) Conference. Boston. Acknowledgement of Federal Support=No
237. Rasoulkhani, K., BN Logasa, MP Reyes, A Mostafavi (2017). *Agent-based modeling framework for simulation of complex adaptive mechanisms underlying household water conservation technology adoption.* Winter Simulation Conference (WSC 2017). Las Vegas.
238. Rasoulkhani, K., BN Logasa, MP Reyes, A Mostafavi (2017). *Integrated modeling of urban water distribution infrastructure for long-term resilience assessment.* International Workshop on Computing for Civil Engineering (IWCCE). Seattle.
239. Rasoulkhani, K., J Cole, S Sharvelle, A Mostafavi (2017). *Assessment of Dual-Distribution and Decentralize Systems for Resilient Urban Water Infrastructure.* International Construction Specialty Conference. Vancouver.
240. Rasoulkhani, K., Logasa, B., Presa Reyes, M., and Mostafavi, A. (2017). Agent-based Modeling Framework for Simulation of Complex Adaptive Mechanisms Underlying Household Water Conservation Technology Adoption. ASCE International Conference on Sustainable Infrastructure, October 2017, New York, New York.
241. Rasoulkhani, K., BN Logasa, MP Reyes, A Mostafavi (2017). *Agent-based modeling framework for simulation of complex adaptive mechanisms underlying household water conservation technology adoption.* Winter Simulation Conference (WSC 2017). Las Vegas.
242. Rasoulkhani, K., MP Reyes, A Mostafavi (2017). *Emergence of Resilience from Infrastructure Dynamics: A Simulation Framework for Theory Building.* International Workshop on Computing for Civil Engineering (IWCCE 2017).
243. Rasoulkhani, K., Presa Reyes, M., and Mostafavi, A. (2017). "Emergence of Resilience from Infrastructure Dynamics: A Simulation Framework for Theory Building." ASCE International Workshop on Computing in Civil Engineering, June 2017, Seattle, WA.
244. Rasoulkhani, K., A Mostafavi (2018). *Long-term performance and life-cycle cost assessment of dual vs. singular water distribution infrastructure systems.* ASCE Construction Research Congress (CRC 2018). Seattle.
245. Rasoulkhani, K., Mostafavi, A., and Sharvelle, S. (2019). "A Computational Simulation-Based Comparison of Dual and Singular Water Distribution Infrastructure Systems for the City of Fort Collins, Colorado." ASCE International Conference on Computing in Civil Engineering, June 17–19 2019, Atlanta, GA.
246. Rasoulkhani, K., Mostafavi, A., Presa Reyes, M., and Batouli, M. (2020). "Simulation-based Assessment of Adaptive Planning in Coastal Water Supply Infrastructure Systems," ASCE Construction Research Congress 2020, March 8-10, 2020, Tempe, Arizona.
247. Ripplinger J and GD Jenerette. Dimensions of urban tree biodiversity are inversely related across continental-scale climate gradients. Ecological Society of America, Portland, OR August 2017
248. Ripplinger J, GD Jenerette, J Wang, M Chandler, C Ge, S Koutzoukis. Understanding Climate Variability of Urban Ecosystems Through the Lens of Citizen Science. American Geophysical Union, New Orleans LA December 2017

249. Rockhill, Tyler, Meixner Thomas, 2017, Investigating the relationship between hydrology and biogeochemistry in semi-arid Urban Green Infrastucture, El Dia Del Agua Y Atmosfera, University of Arizona, Tucson, AZ March 27, 2017.
250. Rochford M, Ibsen P, Jenerette D. (2016) "Species Richness and Functional Trait Diversity for Plants in Southern California's Green Infrastructure along a Climate Gradient" AGU Fall Meeting 2016. San Francisco. (Poster)
251. Santelmann, M., Haggerty, R., Hulse, D., Conklin, D., Wright, M. (2017). Project D1-1: UWIN Envision Modeling of Present and Future Values for Sustainable Water Management Blueprint Indicators. Brief prepared for Urban Water Innovations Network, Annual Meeting, Ft. Collins, Colorado. August, 2017.
252. Santelmann, M.V**.,** D. Hulse, D. Conklin, B. Fulfrost, M. Harrison, M. Wright and R. Haggerty. Multi-scale modeling of Urban Water Systems**.** UWIN Thrust C-D Webinar October 19, 2017.
253. Santelmann, M., D. Hulse, D. Conklin, B. Fulfrost, M. Harrison, M. Wright and R. Haggerty. 2017. Modeling innovation in urban water systems. American Water Resources Association meeting, Portland Oregon, Nov. 6-10 2017. (Oral Presentation)
254. Santelmann, M.V**.,** D. Hulse, D. Conklin, B. Fulfrost, M. Harrison, M. Wright and R. Haggerty. 2018. Multi-scale modeling of Urban Water Systems**.** USGS Winter Seminar Series, Portland Oregon January 23, 2018.
255. Santelmann M V, Hulse D, Wright M, Branscomb A, Enright C, Talal M and Tchintcharauli-Harrison M. 2019. International Geodesign Collaboration: Innovation in Urban Water Systems. February 2019, Redlands, CA
256. Santelmann M V, Hulse D, Wright M, Branscomb A, Enright C, Talal M and Tchintcharauli-Harrison M. 2019. International Geodesign Collaboration: Innovation in Urban Water Systems (Poster). February 2019, Redlands, CA
257. Santelmann, M.V. 2019. Evaluating biodiversity as a co-benefit of innovative water management solutions in urbanizing areas. Ecological Society of America, August 11-16, 2019, Louisville, KY.
258. Santelmann, M. 2020. It's Not Easy Being Green. Presentation to the Geography Program, Oregon State University. Virtual Presentation October 2020.
259. Santelmann, M., Maria Wright, Michael Tchintcharauli-Harrison, Michelle Talal, Hattie Greydanus. 2020. Impacts Of Development And Climate Change At Multiple Scales In Oregon. American Geophysical Fall Meeting December 2020. Oral Presentation.
260. Sarango, M., S. Clark, N. Faynshteyn, K. O'Donnell, S.L. Harlan (2018). *Narratives of water injustice across U.S. urban areas.* AAG Annual Meeting. New Orleans.
261. Sarango, M., D. Kim, L. Senier, S. Harlan (2019). "Unaffordable Water in the U.S.: A Public Health & Health Equity Issue." Poster presentation at the American Public Health Association Annual Meeting, Philadelphia, PA, November 5, 2019.
262. Schoner, B., M. Wright and M. Santelmann. 2018. Integrated Urban Water Model in the Pacific Northwest. Pacific Northwest Water Research Symposium. Oregon State University. April 23-24 2018.
263. Sharvelle, S., N. Ashbolt, E. Clerico, R. Holquist, H. Leverenz and A. Olivieri (2017) *Risk Based Framework for the Development of Public Health Guidance for Decentralized Non-potable Water Systems*, WEFTEC 2017, Chicago, IL.
264. Sen, Roshmi, E. Teitelbaum, and F. Meggers. 2021. "Community Cooling Infrastructure from Waste Heat among Diverse Building Types in Rourkela Steel Township, India." In Journal of Physics: Conference Series, 2069:012218. IOP Publishing.
265. Sharvelle, S., N. Ashbolt, E. Clerico, R. Holquist, H. Leverenz and A. Olivieri (2017) *Risk Based Framework for the Development of Public Health Guidance for Decentralized Non-potable Water Systems*, International Water Association Conference on Water Reclamation and Reuse, Longbeach, CA.
266. Sharvelle, S. (2017) *Developing Guidelines for Performance of Decentralized Non-Potable Water Systems,* WE&RF Onsite Systems Workshop, Los Angeles, CA.
267. Sharvelle, S., M. Arabi, M. Sukop (2018) The National Science Foundation's Research Networks Program, Resilient Utility Coalition – Operationalizing Resilience Summit, Miami, FL.
268. Sharvelle, S., R. Luthy, P. Dillon (2019) "Urban Stormwater to Enhance Water Supply", Groundwater Protection Council, Oklahoma City, OK.

269. Sharvelle, S. (2019) Fostering Fit for Purpose Use of Alternate Water Sources via Health Risk Based Treatment Targets, Water Now Alliance, Austin, TX.
270. Sharvelle, S. E., Water Conference, "Overcoming Challenges for Food-Energy-Water Resource Management in Arid Regions," American Institute of Chemical Engineering, web meeting, United States. (December 2020).
271. Sharvelle, S. E., Neale, M. R., Arabi, M., "Assessing Regional Tradeoffs for Fit-for-Purpose Water and End-Use Efficiency," International Environmental Modelling and Software Society, Brussels, Belgium. (December 2, 2020).
272. Sharvelle, S., FEW Nexus Conference, "Integration of Technological Innovation and Policy Solutions for Food-Energy-Water Resource Use Efficiency". (February 2021)
273. Smith, J.A., A.J. Miller, M.L. Baeck, M.M. Chaney, and Y.Su, 2018. *How Does it Rain Hard? The Ellicott City, Maryland Storms of 30-31 July 2016 and 27 May 2018*. Abstract H11K-1613 Fall 2018 Annual Meeting, AGU, Washington, D.C., 10-14 Dec
274. Solis-Arroyo, Sheila Comparative Assessment of Water Quality at the Rainwater-Harvesting Basin and Neighborhood-Wash Scales– Arizona Hydrological Society Annual Symposium, Phoenix AZ, September 20, 2018.
275. Stephens, T. and Bledsoe, B. (2016). An assessment framework for increased resilience to urban flooding under non-stationarity. University of Georgia Sustainability Summit.
276. Stephens, T., B.P Bledsoe, A.J. Miller, and G. Lee, 2017. Mapping Flood Hazards Under Uncertainty Through Probabilistic Flood Inundation Maps. Abstract , Fall 2017 Annual Meeting, AGU, New Orleans, LA 11-15 Dec.
277. Stephens, T., B.P Bledsoe, A.J. Miller, and G. Lee, 2018. Mapping Flood Hazards Under Uncertainty Through Probabilistic Flood Inundation Maps. Platform Presentation, 12th Annual Meeting, Georgia Association of Floodplain Management, Athens, GA 20-22 Mar.
278. Stephens, T., & B. Bledsoe. 2018. *Mapping flood hazards under climate, land use, and geomorphic uncertainty through probabilistic flood inundation maps*. Presentation, 18th Annual Meeting of the American Ecological Engineering Society (AEES), "Ecological Engineering: Addressing Uncertainty in a Dynamic World," Houston, TX, June 12-14.
279. Stephens, T., & B. Bledsoe. 2018. *Mapping flood hazards under precipitation and land use uncertainty through probabilistic flood inundation maps*. Presentation, American Society of Civil Engineers (ASCE) International Low Impact Development Conference, Nashville, TN, August 12-15
280. Stephens, T., D. Fitzpatrick, H. Hall, & B. Bledsoe. 2018. *Confidence bounds on freeboard at stream crossings for evaluating overtopping risk*. Presentation, 8th Biennial National Hydraulic Engineering Conference (NHEC), "Advancing Hydraulic Engineering through Innovation & Resilient Design," Columbus, OH, August 28-31
281. Stephens, T., & B.P. Bledsoe. 2018. *Mapping flood hazards under climate, land use, and geomorphic uncertainty through probabilistic flood inundation maps*. Poster (EP11E-2095), 2018 AGU Fall Meeting, Washington, DC, December 10-14.
282. Stephens, T.A. and Bledsoe, B.P. 2019. Informing floodplain management and hazard communication through probabilistic flood inundation maps. Presented at the 2019 Conference of the Association of State Floodplain Managers, Cleveland, Ohio 19-23 May.
283. Stephens, T.A., and Bledsoe, B.P. The uncertainty and severity of flood hazard estimates under nonstationarity. Poster presented at the 2019 National Science Foundation Research Meeting - Urban Water Innovation Network, Fort Collins, CO, 30 July - 1 August.
284. Stuhlmacher, M., C. Wang, M. Georgescu, B. Tellman, R. Balling, N. E. Clinton, L. Collins, R. Goldblatt, G. Hansen: Toward a 30m resolution time series of historical global urban expansion: exploring variation in North American cities. Session: Urban Areas and Global Change II, AGU Fall Meeting, 12-16 December 2016, San Francisco.
285. Sukop, M.C., A.D. Henry, J. Bolson, N. Schneider, and T. Kirby (2018). *Using Social Network Analysis to Identify and Understand Linkages Between Climate-related Organizations in Southeast Florida,* University of Florida Water Institute 2018 Symposium, February 6-7, Gainesville, Florida. http://archives.waterinstitute.ufl.edu/symposium2018/downloads/2018BookOfAbstracts.pdf
286. Swartz, Samantha - Evaluating Rainwater-Harvesting Basin Curb-Cuts: How Volunteer Maintenance

Impacts Infiltration Rates. Presentation at El Dia Del Agua y la Atmosfera, Department of Hydrology and Atmospheric Sciences, Tucson AZ, University of Arizona April 9,2018.
287. Swartz, Samantha- Infiltration rates of green infrastructure curb-cut basins: Finding a balance between functionality and aesthetics, Presentation at El Dia Del Agua y la Atmosfera, Department of Hydrology and Atmospheric Sciences, Tucson AZ, University of Arizona March 25, 2019.
288. Taha, Fatima. 2021. Using a Serious Game to Communicate the Effects of Bioswales. Pacific Northwest Research Symposium April 12-13 2021. Virtual Meeting hosted by Oregon State University Corvallis OR
289. Talal, M. and M. Santelmann. 2017. Vegetation biodiversity patterns and ecosystem functioning in various types of green infrastructure in Portland, OR. Poster presented at Urban Ecosystem Research Consortium. Portland, OR. February 6, 2017. Portland, OR.
290. Talal, M. and M. Santelmann. 2017. Vegetation biodiversity patterns and ecosystem functioning in various types of green infrastructure in Portland, OR. Poster presented at Urban Ecosystem Research Consortium. Portland, OR. February 6, 2017. Portland, OR.
291. Talal, M. and M. Santelmann. 2017. Vegetation biodiversity patterns and ecosystem functioning in various types of green infrastructure in Portland, OR. Poster accepted for Ecological Society of America meeting, Portland, OR. August 6, 2017.
292. Talal, M. and M. Santelmann. 2018. Plant greenness and health of various income-level neighborhoods in Portland, OR using Landsat 8 OLI/TIRS surface reflectance. Oral presentation at Urban Ecosystem Research Symposium, Portland, Oregon. Feb 5 2018.
293. Talal M, 2018. Comparison of plant greenness among neighborhoods of different income-levels in Portland, Oregon using Landsat 8 OLI/TIRS surface reflectance. Research Advances in Fisheries, Wildlife, and Ecology Symposium (Poster), April 2018, Corvallis, OR
294. Talal M. 2018. Comparison of plant greenness among neighborhoods of different income-levels in Portland, Oregon using Landsat 8 OLI/TIRS surface reflectance. Pacific Northwest Water Research Symposium (Oral), April 2018, Corvallis, OR
295. Talal, M. and M. Santelmann. 2018. Plant greenness of different income-level neighborhoods in Portland, Oregon using Landsat 8 OLI/TIRS surface reflectance. Oral presentation accepted for Ecological Society of America meeting, New Orleans, LA. August 2018.
296. Talal M, Santelmann M. 2018. Comparison of plant greenness among neighborhoods of different income-levels in Portland, Oregon using Landsat 8 OLI/TIRS surface reflectance Ecological Society of America Annual Conference (Oral), August 2018, New Orleans, LA
297. Talal M, Santelmann M. 2019 Plant community composition patterns in urban parks of Portland, Oregon Urban Ecology and Conservation Symposium (Oral), February 2019, Portland, OR
298. Talal., M.L. 2019. Exploring urban parks: plant communities, visitor experiences, and manager perspectives in Portland, Oregon. Israeli Ministry of Agriculture (Invited Seminar), December 2019, Tel Aviv, Israel.
299. Talal, M.L. 2019. Exploring urban parks: plant communities, visitor experiences, and manager perspectives in Portland, Oregon. Hebrew University of Jerusalem Geography Department (Invited Seminar). November 2019, Jerusalem, Israel.
300. Talal, M.L. and M.V. Santelmann. 2019. Plant community composition patterns in urban parks of Portland, Oregon. Ecological Society of America August 11-16 2019, Louisville, KY.
301. Talal, M.L. and M.V. Santelmann. 2020. Urban park visitor preferences for vegetation – an on-site qualitative research study in Portland, Oregon. Urban Ecosystem Research Consortium Symposium, March 2, 2020, Portland, OR.
302. Talal, M.L. and M.V. Santelmann. Oregon State University. 2020. Innovations in Urban Water System. International GeoDesign Collaborative Summit, February 21-23, 2020, Redlands, CA.
303. Talal, M.L. and M.V. Santelmann. 2020. Plant community composition patterns in urban parks of Portland, Oregon. Weizmann Institute of Science Israel Plant Ecology Conference, February 10-11, 2020, Rehovot, Israel.
304. Talal, M.L. and M.V. Santelmann. 2022. Visitor access, use, and desired improvements in urban parks. The Nature of Cities Festival. May 29 – 31, 2022. Virtual.
305. Talal, M.L. and M.V. Santelmann. 2022. Visitor access, use, and desired improvements in urban parks. Urban Ecosystem Research Consortium Symposium, May 7 – 8, 2022. Portland, OR.

306. Talebpour, M., C. Welty and E. Bou-Zeid. (2016) “Land-Atmosphere-Hydrosphere Interactions in Urban Terrains”. Abstract H13C-1375 presented at the Fall 2016 Meeting of the American Geophysical Union, December 12-16, 2016, San Francisco, CA. https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/188199.
307. Talebpour M., Welty C., and Bou-Zeid E. (2018) “Modeling coupled atmospheric-hydrological processes in urban areas”. Fall meeting of the American Geophysical Union, Washington DC, https://agu.confex.com/agu/fm18/meetingapp.cgi/Paper/413748
308. Talebpour M., Welty C., and Bou-Zeid E. (2019) “Development and testing an urban hyper-resolution fully-coupled subsurface-land surface-atmosphere model”. 21st Annual Meeting of the Baltimore Ecosystem Study (BES) Long-Term Ecological Research Project, Baltimore, MD, USA
309. Talebpour M., Welty C., and Bou-Zeid E. (2019) “Development and evaluation of a new fully-coupled urban atmospheric-hydrological model”. Fall meeting of the American Geophysical Union, San Francisco, CA, USA: https://agu.confex.com/agu/fm19/meetingapp.cgi/Paper/615914
310. Talebpour M., Welty C., and Bou-Zeid E. (2020) “A New Fully Coupled Model for Improving the Representation of Urban Heterogeneous Hygrothermal Processes”. 100th Annual Meeting of the American Meteorological Society, Boston, MA, USA: https://ams.confex.com/ams/2020Annual/meetingapp.cgi/Paper/370861
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Technologies & Models

1. **A1-1:** [Software] Heidari, H., Arabi, M., Warziniack, T., Hydroclimatic Assessment Tool, https://hcat.erams.com/docs/
2. **A2-1:** WRF-PUCM-ParFlow: A fully-coupled modeling framework to simulate mass, momentum, and energy budgets in the atmosphere, surface, and subsurface, and from local to regional scales.
3. **A2**-1: Runoff heat full model + Runoff heat reduced model: a numerical model that solves the mass, momentum and heat equations to predict the temperature of hot urban runoff. Full and simplified versions have been developed and tested.
4. **A2**-1: Building model in the large eddy simulation code with heat transfer: This is an advanced implementation of the forces and heat fluxes that buildings impose on the air flow, coupled to a turbulence resolving simulation of the air flow in cities
5. **A2**-1: Princeton Urban Canopy Model – advanced: we added new features to our Urban Canopy model including more thermochromic material, thermal comfort, and better hydrological representation.
6. **A2-4:** Evaporative cooling model built by Teitelbaum of novel membrane building facade created merging Bou-Zeid microclimate model of surface energy interactions with a subsurface model of heat transfer by evaporation behind a porous membrane.
7. **A2-4**: TRNSYS and EnergyPlus building energy simulations tools enable a dynamic iterative annual energy demand simulation platform for detailed building performance models, which can be translated into agglomerated urban performance analysis, and can output data related to energy driven evaporative cooling water use.

4. **A2-4:** Technology Disclosure**:** Meggers, Forrest (2018): Atmospheric water harvesting heat exchanger geometry.
5. **A2-4:** Technology Disclosure: Meggers, Forrest (2021): Atmospheric Longwave and shortwave combined radiant surface scanning apparatus for outdoor radiant field evaluation.
8. **B1-1a:** Integrated Urban Water Model (IUWM): The purpose of IUWM is to forecast urban water demand and project potential savings from conservation and use of alternative water sources over varying climatic conditions and land uses. Water supply and demand assessment under alternative climate, land use and population scenarios is an area of great interest among urban planners and water managers. The Integrated Urban Water Model (IUWM) was developed for urban water demand and savings forecasting with urban water conservation and recycling practices. The purpose of the mass balance model is to allow evaluation of alternative urban water management strategies under varying climatic conditions at a municipal or regional scale. IUWM has been deployed as an online tool and as a web service, thus enabling accessibility, ease of use and applicability at the municipal scale. IUWM facilitates the development of urban water demand forecasts through automated retrieval of publicly available data inputs through a geographical information system (GIS) interface, thus relieving the need for manual input of data. Indoor residential demands are forecast based on end-use at the census block level with population and household data retrieved from the United States census. Combined residential/commercial, industrial, and institutional (CII) irrigation demands are forecast based on daily evapotranspiration and land cover data. Water management strategies included in IUWM are:
    - Indoor conservation
    - Irrigation conservation
    - Graywater reuse for toilet flushing and irrigation
    - Stormwater capture and use
    - Wastewater treatment plant (WWTP) effluent reuse
    - More Information: https://erams.com/catena/tools/urban-planning/urban-water-demand-forecasting/
    - Domain: www.erams.com/iuwm
9. **B1-1a:** Community Life Cycle Assessment for Stormwater Infrastructure Tool (CLASIC): The CLASIC tool serves as a screening tool utilizing a lifecycle cost framework to support stormwater infrastructure decisions on extent and combinations of green, hybrid green-gray and gray infrastructure practices. The tool is hosted on the eRAMS platform so that it will be geographical information system (GIS) interfaced and include interaction with national databases to upload data for the modeled area. There are three main components to the CLASIC tool outputs; life cycle costs (LCC), triple bottom line analysis (TBL) and performance (hydrologic and water quality). CLASIC is currently undergoing beta testing by user groups and will be posted as a publicly available web tool in 2019. More information: http://onewatersolutions.com/research/clasic/
10. **B1-2:** WEST/WWEST decision support tools: https://west.berkeley.edu/
11. **B2-2b: Flood Mapping:** We developed a probabilistic floodplain mapping framework based on Monte Carlo simulations of flood hydraulics that accounts for uncertainty in model inputs and parameters.
12. **B2-2b: High Resolution Topography:** We collected UAV imagery processed using Structure from Motion (SfM) software to generate high-resolution topographic point clouds used in 2-D hydraulic models of flood waves routed through pre- and post-restoration channel/floodplain systems
13. **B2-2b**: **Channel Stability Tools:** We updated the existing Capacity-Supply Ratio (CSR) tool to assess channel stability by accounting for sediment transport processes.
14. **B2-2b:** River Erosion Model (REM) http://www.github.com/rodlammers/REM
15. **C2-1: Choiceflow Model:** The research uses an innovative approach that guides participants through a computer simulation program, Choiceflow, to simulate future conditions where choices about technology/policy must be made. By studying individuals' decision-making behaviors, such as information seeking behaviors, investment choices, support for policy, and perceptions of strategies/technologies, we can improve our understanding of the likelihood of adoption of different urban water management practices and the barriers that might inhibit widespread adoption. Using this information, we suggest

strategies for policy and investment that incorporate peoples' preferences and decision-making biases, making them more likely to be accepted.

16. **D1-1:** UWINvision model, developed through the incorporation of the SWMM-5 Model into the agent-based model, Envision, for improved accuracy of hydrologic modeling of areas undergoing urban development.

17. **D1-1**: Preparation of code for SWMM-5 and EPANET for incorporation into web services.
18. **D1-1**: Game app for a mobile phone that explores impact of different types of urban development (streets, wetlands, bioswales, housing units) on key indicators that sum to give the player a score.
19. **D1-2:** The Water Rights Analysis tool helped to identify and explore water rights, appropriated amounts in the Colorado region. Domain: erams.com/wra
20. **D1-2/D1-3:** [Software] Dell, T., S. Sharvelle, and M. Arabi, 2020, Community-Enabled Lifecycle Analysis of Stormwater Infrastructure Cost (CLASIC) Model, https://clasic.erams.com/
21. **D1-2/D1-3:** [Software] Wible, T. and M. Arabi, 2020, River Discharge and Water Quality Analysis Tool, https://erams.com/catena/tools/water-quality/
22. **D1-2/D1-3:** [Software] Sharvelle, S. and M. Arabi, 2020, Urban Water Demand Forecasting Model, https://erams.com/catena/tools/urban-planning/urban-water-demand-forecasting/
23. **D1-2/D1-3:** [Software] Fontaine, D. and M. Arabi, 2020, Pipe Renewal Prioritization Model, https://erams.com/catena/tools/urban-planning/pipe-renewal-prioritization/
24. **D1-2/D1-3:** [Software] Wible, T., R. Morrison, and M. Arabi, 2020, River Hydraulics & Sediment Transport Model, https://erams.com/catena/tools/river-basin-planning/hydraulics/
25. **D1-2/D1-3:** [Software] Wible, T., R. Morrison, and M. Arabi, 2020, Watershed Rapid Assessment Program (WRAP) Model, https://erams.com/catena/tools/colorado-collaborative/watershed-assessment/
26. **D1-3:** The WaterConnect application was built and serves UWIN research model and data output across the nation within a geospatial interface. Domain: erams.com/water-connect. A MongoDB data store on Colorado State University holds large datasets including climate and water end-use model output. This resource is available through web-services:
    - http://csip.engr.colostate.edu:8083/csip-climate/m/prism/1.0
    - http://csip.engr.colostate.edu:8083/csip-climate/m/maca/2.0
    - http://csip.engr.colostate.edu:8083/csip-climate/m/maca/2.0
    - http://csip.engr.colostate.edu:8092/csip-daycent/m/daycent/2.0
    - https://csip.erams.com/csip-iuwm/m/iuwm/1.0

Websites

1. UWIN SRN Website: https://erams.com/UWIN/
2. UWIN YouTube Channel: https://www.youtube.com/channel/UC7nNrIUznXii6_u0axbhQrA
3. UWIN Zotero Publication Database: https://www.zotero.org/groups/urban_water_innovation_network_uwin/items
4. UWIN Urban Sustainability Data Hub: https://erams.com/UWIN/data/

Webinars

A total of 51 webinars, 43 research and 8 stakeholder presentations, have been published by the UWIN SRN. More information is available here: https://erams.com/UWIN/webinars/

In the spring of 2017 UWIN launched the Networks' first Webinar Series focused on Urban Water Innovation Research Innovations. A total of four series organized by UWIN's current research thrusts were held from April through November, 2017. The webinars include a 45-minute presentation of the specified UWIN related research, followed by a 15-minute Q&A session. The webinars were recorded and are available on the One Water Solutions Institute YouTube Channel

In the spring of 2018, we implemented the One Water Perspectives series, featuring presentations from thought leaders, regional managers, policy makers and practitioners. The series engages members of the UWIN Regional

Stakeholder Advisory committees and explores activities, plans, lessons learned, and opportunities currently underway in each UWIN study region. Topics range from adaptive water supply planning and resilience infrastructure to integrated management and scenario planning as well as resource recovery, technological advancements and diffusion of innovation. The series is currently underway and will continue through the summer. These are also webinars recorded and available on the One Water Solutions Institute YouTube Channel.

In 2021-2022 UWIN developed a "Science Talk" webinar series designed to highlight key findings of the research, impacts, and implications of the results, and pragmatic recommendations for stakeholders and practitioners. The series includes a total of 24 webinars covering research project along with our education and stakeholder outreach program activities.

Outreach Materials

A variety of outreach and print materials have been published for broadly disseminating information about UWIN. The materials can be accessed from the "Product" menu on the home page of the website: https://erams.com/UWIN/print-materials/

Project Landing Pages (21): Landing pages for each of the 21 UWIN research projects were enhanced to include the projects' contacts, summary materials, imbedded webinar recordings, publications and other relevant information. You can access the individual research landing pages from the main project page: https://erams.com/UWIN/research-projects/

Project cards (21): Co-PI Santelmann of the OSU team and Sarah Millonig, UWIN Program Coordinator, developed a set of project-description cards that list every project in all four project thrusts, with concise characterization of the titles, goals and specific objectives and relevant graphics. The cards are communication tools to be used in meetings with the stakeholders, as an easy way to track and organize the complex set of projects that comprise the UWIN at the national level.

Project Catalogs (20): Sarah Millonig, UWIN Program Coordinator, developed two-page project overviews for each of the UWIN Research Projects. These documents are used during stakeholder engagement meetings and data request meetings. They are available on each project's individual landing page. In addition, an overview document was created to briefly summarize the major goals and objectives of the UWIN SRN. A comprehensive catalog is also available providing a description of both the entire program as well as the individual research projects.

Quad Summaries (23): Each project has provided a 2-page progress update summarizing major accomplishments, products and participants. These are updated annually.

Annual Reports (6): In addition to the annual report submitted to the National Science Foundation, UWIN prepares and disseminates a document containing a detailed summary of activities, results and accomplishments over the previous year. The report also provides a detailed list of partners and collaborators as well as a current list of UWIN-related research products including academic publications, conference papers and proceedings, websites, models and other related products.

Data

Urban Sustainability Data Hub: UWIN's research activities have culminated in significant scientific advancements that enhance our understanding of urban water systems. The Network has generated extensive amounts of urban sustainability data and has been working to publish an **Urban Sustainability Data Hub**, which catalogs project metadata and provides access to data sets produced by UWIN. Each data product includes metadata and access to the raw data, once published. UWIN has partnered with the Urban Resilience to Extremes (UREx) SRN to jointly undertake and fund this effort with assistance from a post-doc shared between the two SRNs. More information is available at: https://erams.com/UWIN/data/

CATEGORY	TOTAL
Climate Assessment & Projections	**5**
Urban Climate Data	**6**
Water Supply & Demand	**5**
Sociopolitical Information	**4**
Microclimate	**2**
Urban Infrastructure	**4**
Green Infrastructure	**4**
Flooding	**3**
Energy Usage	**1**
Census	**2**
Land Use and Land Cover	**2**
Hydrology	**1**
UWIN Urban Water Sustainability Indicators Survey	**1**
TOTAL	**40**

Published Datasets

A2-2:

- Krayenhoff, E. S., Moustaoui, M., Broadbent, A. M., Gupta, V., and Georgescu, M (2018). Diurnal interaction between urban expansion, climate change and adaptation in 21st century U.S. cities, Nature Climate Change, 8: 1097–1103. DOI: 10.1038/s41558-018-0320-9.

- All relevant surface and upper-air continental US climate data has been uploaded to and published (under a DOI) at Arizona State University Libraries. This data has been published under FAIR principles, and is freely available and citable by any researcher: https://dataverse.asu.edu/dataset.xhtml?persistentId=doi:10.48349/ASU/3TYXZI

B1-1a:

- Chinnasamy, C. V., M. Arabi, S. Sharvelle, T. Warziniack, C. D. Furth, A. Dozier (2021). Data for Characterization of Municipal Water Uses in the Contiguous United States, HydroShare, https://doi.org/10.4211/hs.feb5af8990914ce2b28f18b10d65c2a2

D1-1:

- Hulse, D., Enright, C., Branscomb, A., Santelmann, M., Wright, M. 2018. Multiscale Scenario Narratives for 2060 Urban Water Management, Willamette River Basin. Institute for a Sustainable Environment, University of Oregon. Narrative description and data matrix for three alterative futures.

- Hulse, D., Enright, C., Branscomb, A., Santelmann, M., Wright, M. 2018. Land Use Land Cover for 2010 and three 2060 Alternative Future Scenarios, Chicken Creek Watershed near Sherwood, Oregon (10m raster data layers). Institute for a Sustainable Environment, University of Oregon.

- Hulse, D., Enright, C., Branscomb, A., Santelmann, M., Wright, M. 2018. Neighborhood Site Plans for 2010 and three 2060 Alternative Future Scenarios, West Sherwood Neighborhood, near Sherwood, Oregon. (polygon shapefiles). Institute for a Sustainable Environment, University of Oregon.

Invited Seminars & Lectures

A2-1:

1. Mack, E.A. Water Affordability Assessments and Solutions. Vanderbilt University October 4, 2019
2. Interview on Sirius XM Radio about Water Affordability and Conserving Water for Doctor Radio April 19, 2019
3. Mack, E. (2021). Environmental Justice and Urban Innovation: Understanding Water Bill Affordability and Responses to Rising Water Rates. Hydrology Seminar Series, Portland State University, United States Geological Survey (USGS), and Oregon State University. April 21, 2021.
4. Wrase, S. and E. Mack. (2017) Underground and Overlooked: America's Wastewater Infrastructure Crisis. Michigan State University Undergraduate Research and Arts Forum (*UURAF*).
5. Mack, E.A. Water Affordability Assessments and Solutions. Vanderbilt University October 4, 2019
6. A Spatio-temporal Perspective on Water Scarcity Induced Risk from Global to Local Scales. Future of Water Institute, University of Capetown, South Africa. June 26, 2019.
7. Interview on Sirius XM Radio about Water Affordability and Conserving Water for Doctor Radio April 19, 2019
8. Water Rates in Detroit. Global Water Justice Summit: The Michigan Conference January 24-25, 2019
9. Human Dimensions of the Urban Water Innovation Network (U-WIN). Earth and Environmental Sciences Seminar Series, Wayne State University. March 7, 2018.
10. A Vulnerability Assessment of Water and Wastewater Affordability for Residential Consumers. Health and Environmental Funders Network (HEFN) Water and Water Affordability Webinar. September 21, 2017.
11. Presentation at 60th Annual Regulatory Studies Program, "CAMP NARUC" Michigan State University, August 9, 2017
12. Water and Wastewater Affordability for Residential Consumers. Kiwanis Club, East Lansing. July 24, 2017
13. The Socio-Economics of Water: Thinking Locally and Regionally. U-WIN Webinar Series. April 27, 2017
14. Panelist: Conversation with the Cities: Building Water Resilient Communities. All About Water 2.0. Wayne County Community College, MI (March 19).

A2-2:

15. Georgescu M (2019), Sustainable Urban Systems – A Climatic Perspective, Invited Speaker for Department of Civil and Environmental Engineering Seminar Series, University of Illinois at Urbana-Champaign, Thursday March 28, 2019 (Univ. Illinois Invited Civil and Environmental Engineering Invited Seminar speaker).
16. Georgescu M. (2018), Urban systems and Urban Climate: at odds or in sync? Monday, August 27, 2018 (Invited Presentation for Bucharest Urban Climate Summer School, Bucharest, Romania).
17. Georgescu M. (2018), The utility of computational modeling to address urban environmental sustainability, Monday, August 27, 2018 (Invited Presentation for Bucharest Urban Climate Summer School, Bucharest, Romania).
18. Krayenhoff, E.S. Can we adapt our cities to the coming heat? Department of Geography, Western University, 8 Feb 2019 (Western University Invited Seminar speaker)

A2-3:

19. Hondula DM (Apr. 2021). Heat, water, and urban climate: Phoenix perspectives. University of Virginia Undergraduate Research Seminar, virtual presentation.

20. Hondula DM (Mar. 2021). Water as a critical resource for urban heat resilience. Oregon State University Water Engineering Seminar, virtual presentation.
21. Hondula DM (Aug. 2018). Measuring and modeling personal heat exposure in urban environments. Bucharest Urban Climate Summer School, Bucharest, Romania.
22. Hondula DM (Aug. 2018). Attribution of heat-related mortality to urban heat effects in Maricopa County, AZ. University of Georgia Climate and Health Seminar, Athens, Georgia, USA.
23. Hondula DM (Jun. 2019). Tackling the urban heat challenge. City of Tucson 11th Annual Urban Heat Island Workshop, Tucson, Arizona, USA.
24. Hondula DM (Sept. 2018). On the front lines of urban warming. New Mexico State University Climate Change Seminar Series, Las Cruces, New Mexico, USA.
25. Hondula DM (Aug. 2017). Measuring and modeling personal heat exposure in urban environments. Bucharest Urban Climate Summer School, Bucharest, Romania

B2-2a:

26. Results from the flood analysis in Athens-Clarke County (ACC) were presented to the ACC Greenways Commission. They are interested in using the results to help prioritize projects to protect riparian areas and reduce flood impacts on vulnerable communities. The work was also publicized by AT&T through a press release (part of the work was funded through an AT&T Climate Resiliency Community Challenge grant program).
27. Miller was a member of the organizing team and convened a flood science session and presented the overview (including current research findings) at the July 2020 Baltimore Flood Science and Policy Workshop, which focused on gaps between current science and management policy; participants included state, local and federal government as well as community groups. This work is ongoing and will include future workshops on social vulnerability to flood hazards.
28. With collaboration between our UWIN project and a Chesapeake Bay Trust project led by colleagues at Virginia Tech, Minebank Run in Baltimore County is being developed as a "testbed" watershed for analysis of what can or cannot be done to remedy flood impacts through upstream stormwater management and channel-floodplain restoration projects using streamflow and precipitation records, land-use change analysis, hydrologic and hydraulic models, and comparison of high-resolution topographic data with LiDAR data to assess channel response to continuing flood flows and post-construction impacts on stream restoration. Work continuing this year will lead to a presentation for county agencies charged with resource protection.

B4-1:

29. Jones, Kimberly (2020). "Intersection of Water Research and Policy", Chesapeake Water Environment Association, June 18, 2020.
30. Jones, Kimberly (2021). "Environmental Justice: Role of science, engineering, and policy in ensuring equity in urban water systems", Fall 2021 ACS Meeting: Resilience of Chemistry, August 22 – 24, 2021

Special Reports

1. Arabi, M., Dezfooli, D., Macpherson, G., Millonig, S. (2021). One Water Cities: Development of Guidance Documents and Assessment Metrics: Literature Review. WRF Project 4969. The Water Research Foundation. https://www.waterrf.org/research/projects/one-water-cities-development-guidance-documents-and-assessment-metrics
2. Contorno L., M. Sarango, S.L. Harlan. "Environmental Justice and Sustainable Urban Water Systems: Community Voices from Selected Cities in the United States." Social Science Environmental Health Research Institute, Northeastern University, Boston, MA (October 2018) www.northeastern.edu/environmentalhealth/UWIN_Report.pdf
3. Sturm, H. and M. Davis. "The Human Right to Water: A Guide to Using Freedom of Information Laws to Understand Rising Water Rates." The Northeastern University School of Law, Program on Human Rights and the Global Economy, Boston, MA (March 2019).

https://lawprofessors.typepad.com/human_rights/2019/03/world-water-day-and-the-human-right-to-water-knowledge-is-power.html

Press Releases, News Articles & Media Mentions

UWIN SRN Award – Colorado State University:

1. "CSU receives $12 million for urban water sustainability research" (2015) http://source.colostate.edu/csu-receives-12-million-for-urban-water-sustainability-research/
2. "NSF network tackles urban water problems" (2016) http://source.colostate.edu/water-water-everywhere-and-many-problems-to-solve/

A1-2:

3. Akpan, N. (2017, January 26). Affordable water may soon dry up, especially if you live here. Retrieved from PBS News Hour: http://www.pbs.org/newshour/updates/affordable-water-may-soon-dry-especially-live/
4. Blythe, M. (2017, January 16). U.S. Water Crisis: Millions Can't Afford Water Five Years From Now. Retrieved from Counsel & Heal: http://www.counselheal.com/articles/30368/20170116/us-water-crisis-millions-cant-afford-water-five-years-from-now.htm
5. Collins, N. (2017, January 29). How long will we be able to afford water? Retrieved from The Week: http://theweek.com/articles/674401/how-long-able-afford-water
6. Cousins, F. (2017, January 22). Americans Are Being Priced Out Of Water Affordability, Millions Could Lose Service. Retrieved from The Ring of Fire Network: https://trofire.com/2017/01/22/americans-priced-water-affordability-millions-lose-service/
7. Cwiek, S. (2017, January 13). MSU researchers: Water could be unaffordable for more than 35% of U.S. households in 5 years. Retrieved from Michigan Radio: http://michiganradio.org/post/msu-researchers-water-could-be-unaffordable-more-35-us-households-5-years
8. Elizabeth, E. (2017, February 6). PBS: Water Unaffordable for 1/3 of US Households in 5 Years and Will 'Dry Up'. Retrieved from Health Nut News: http://www.healthnutnews.com/pbs-water-will-unaffordable-13-us-households-5-years-dry-shows-new-study/
9. Fosco, M. (2017, January 30). Water Could Become Unaffordable for a Third of American Households. Retrieved from Seeker: https://www.seeker.com/water-could-become-unaffordable-for-one-third-of-american-households-2225981593.html
10. Graham, K. (2017, January 31). Affordable water may become a thing of the past in the U.S. Retrieved from Digital Journal: http://www.digitaljournal.com/news/environment/affordable-water-may-become-a-thing-of-the-past-in-the-usa/article/484863
11. Hays, B. (2017, January 12). Study: U.S. water affordability crisis on the horizon. Retrieved from UPI: http://www.upi.com/Science_News/2017/01/12/Study-US-water-affordability-crisis-on-the-horizon/3511484236130/
12. Henion, A. (2017, January 11). Affordable Water in the US: A Burgeoning Crisis. Retrieved from MSUToday: http://msutoday.msu.edu/news/2017/affordable-water-in-the-us-a-burgeoning-crisis/
13. Huff, E. (2017, February 2). Third world status: 30 percent of Americans could soon not afford safe running water. Retrieved from News Target: http://www.newstarget.com/2017-02-02-third-world-status-30-percent-of-americans-cant-afford-safe-running-water.html
14. Jeffries, Z. (2017, April 11). What Is It Like to Live Without Running Water? Detroit Families Know. Retrieved from Yes! Magazine: http://www.yesmagazine.org/people-power/what-is-it-like-to-live-without-running-water-detroit-families-know-20170411
15. Lunau, K. (2017, January 17). The Number of US Households That Can't Afford Water Could Triple in Five Years. Retrieved from Vice: Motherboard: https://motherboard.vice.com/en_us/article/the-number-of-us-households-that-cant-afford-water-could-triple-in-five-years
16. Mantey, D. (2017, January 13). Water Will Be Too Expensive for 1/3 of America by 2022. Retrieved from IEN: http://www.ien.com/regulation/video/20848989/ien-now-water-will-be-too-expensive-for-13-of-america-by-2022

17. Monetary Watch. (2017, January 17). One Third of Americans Can't Afford Safe Running Water, MSU Study. Retrieved from Monetary Watch: Financial Truth : http://monetarywatch.com/2017/01/one-third-americans-cant-afford-safe-running-water-msu-study/?doing_wp_cron=1492894120.6433489322662353515625
18. Moss, D. (2017, April 17). Clean Water is a Basic Human Right, and We Can and Should Make It Affordable to Everyone. Retrieved from Ensia: https://ensia.com/voices/clean-water-equality/
19. Muhammad, N. I. (2017, February 7). The high price to pay for water. Retrieved from The Final Call: http://www.finalcall.com/artman/publish/National_News_2/article_103509.shtml
20. O'Rourke, C. (2017, March 5). America's hidden water affordability crisis. Retrieved from Grist: http://grist.org/article/americas-hidden-water-affordability-crisis/
21. Picchi, A. (2017, March 24). Gulp! Water increasingly unaffordable for many Americans. Retrieved from CBS Money Watch : http://www.cbsnews.com/news/are-you-prepared-for-unaffordable-water-bills/
22. Roger, K. (2017, January 19). Can America Afford the High Cost of Replacing Infrastructure? Retrieved from Municipal Sewer & Water: http://www.mswmag.com/online_exclusives/2017/01/can_america_afford_the_high_cost_of_replacing_infrastructure
23. Scrudato, L. (2017, January 13). Could Water Soon Become Unaffordable for U.S. Households? Retrieved from Laboratory Equipment: https://www.laboratoryequipment.com/news/2017/01/could-water-soon-become-unaffordable-us-households
24. Cardno, C. A. (2017). Number of U.S. Households Unable to Afford Water Could Triple. Civil Engineering News. March 2017

A2-1:

25. "Planting Trees To Reduce Urban Heat? Works Better In Dry Climates, Study Finds" (2019) https://www.wwno.org/post/planting-trees-reduce-urban-heat-works-better-dry-climates-study-finds
26. "Solutions to urban heat differ between tropical and drier climes" (2019) https://www.nsf.gov/discoveries/disc_summ.jsp?cntn_id=299172

A2-4:

27. "Meggers wins IP Accelerator Fund to build Spherical Motion Average Radiant Temperature (SMART) building sensor and 3D thermal renderer" (2017) https://chaos.princeton.edu/2017/02/27/meggers-wins-ip-accelerator-fund-to-build-spherical-motion-average-radiant-temperature-smart-building-sensor-and-3d-thermal-renderer/

B1-1a:

28. "Report shows benefits, risks of stormwater and graywater" (2015) http://source.colostate.edu/expanding-water-supplies-report-shows-benefits-risks-of-stormwater-and-graywater/
29. "A new strategy for drought-stressed cities: graywater recycling" (2016) http://theconversation.com/a-new-strategy-for-drought-stressed-cities-graywater-recycling-56564

B1-1b:

30. "Civil engineering student's research evaluates long-term urban water infrastructure resilience" (2020) https://tees.tamu.edu/news/2018/05/civil-engineering-students-research-evaluates-long-term-urban-water-infrastructure-resilience.html

B3-1:

31. "As Sea Levels Rise, Expect More Floods" (2019) https://eos.org/research-spotlights/as-sea-levels-rise-expect-more-floods
32. Mayor de Blasio Releases NYC's First-Ever Citywide Analysis of Rainfall-Based Flooding and Plan for Future Flood Preparedness (2021): https://www1.nyc.gov/office-of-the-mayor/news/367-21/mayor-de-blasio-releases-nyc-s-first-ever-citywide-analysis-rainfall-based-flooding-plan-for

C4-1:

33. "Water: Underpriced, Still Expensive" (2016) http://waterfm.com/water-customer-assistance-programs-affordability/

Citizen Science:

34. "Can We Drink Rain?" (2018) http://www.kunc.org/post/can-we-drink-rain-researchers-take-look
35. "Off the Roof on SciStarter" (2018) https://scistarter.com/project/18259-Off-the-Roof

Undergraduate Research Program

36. "McNair Scholar, Takondwa Musa participates in UWIN Undergraduate Research Program | Ronald E. McNair Postbaccalaureate Achievement" (2019) https://mcnair.rutgers.edu/news/mcnair-scholar-takondwa-musa-participates-uwin-undergraduate-research-program

Awards & Scholarships

1. **A1-2:** 2021 William R. "Randy" Boggess Award for best paper of the year published in the Journal of the American Water Resources Association (JAWRA).
2. **A2-2:** Broadbent, A. M.*, Krayenhoff, E. S., Georgescu, M., (2019). Adaptation to projected 21st century heatwaves in Atlanta, Detroit, and Phoenix. Urban Climate Research Centre Poster Event, March 2019 (*Won first prize in the Postdoctoral category).
3. **B2-1:** Gupta, Neha was awarded a Carson Scholarship - *https://www.carson.arizona.edu/* - this award trains students in science communication and has them present to community groups. They also write broad audience blog and publication articles.
4. **B2-1:** Yang, Bo Yang won Honorable Mention in the Planning Category and 2nd place in the Demonstration Category for their EPA Rainworks projects.