TOWN +GOWN: NYC

Megacities Alliance for Water and Climate (MAWAC) - European North American Region (ENAR)

With UNESCO, Métropole du Grand Paris (MGP), Association Recherche Collectivités dans le domaine de l'Eau, Ile de France (Arceau-IdF), Université Paris-Est Créteil Val de Marne, Laboratoire Eau, Environnement, Systèmes Urbains (LEESU), and International Association of Water & Wastewater Utilities for Sustainable Water Security (W-SMART)

Water Research & Innovation Workshop - March 20 and 21, 2023 (NYU/Tandon + NYC DEP, Co-hosts)

Town+Gown:NYC Master Academic Consortium Contract Research Inventory from Member Institutions

Town+Gown:NYC (https://www.nyc.gov/site/ddc/about/town-gown.page) is a city-wide built environment research program that operates from the New York City Department of Design and Construction (https://www.nyc.gov/site/ddc/index.page). Town+Gown:NYC develops and supports applied built environment research projects, using NYC's built environment as a laboratory for the research.

Town+Gown:NYC's first modality is our experiential learning research component (https://www.nyc.gov/site/ddc/about/Experiential_Learning.page). Town+Gown's second modality is our faculty-directed research component (https://www.nyc.gov/site/ddc/about/Faculty_Research.page), which operates through our innovative master academic consortium contract (Master Contract) with 15 academic institutions that stand ready to propose research solutions in response to NYC agency (and other governmental agency) requests for proposals for funded academic research. The types of academic research NYC agencies have funded is broad and includes water-related research for NYC Department of Environmental Protection (https://www.nyc.gov/site/ddc/about/town-gown-rfps.page).

Below is an inventory of water-related research conducted by the Master Contract schools. The research procured through the Master Contract is highlighted in orange below.

City University of New York

Citywide Stormwater Resiliency Study (Town+Gown Master Contract RFP at https://www.nyc.gov/assets/ddc/downloads/town-and-gown/active-rfps/Citywide%20Stormwater%20Resiliency%20Study%20T+G%20RFP.pdf)

Jennifer Cherrier (Brooklyn College)

Rainfall poses a set of interwoven challenges to New York City that require coordinated solutions, and the City of New York is working to improve water quality and address urban flooding. Improving water quality benefits communities, protects ecosystems, and reduces EPA penalties; control of urban flooding increases safety and limits damage to public and private property, and must be integrated with preparation for coastal surge events like Hurricane Sandy. Integrated stormwater management can address both concerns simultaneously. Significant work in this area is underway, but a better understanding of the Hydraulic and Hydrologic (H&H) systems was needed to coordinate and strengthen initiatives, across agencies, between the public and private sectors, and between resiliency and sustainability initiatives. A combined H&H model was intended support integrated stormwater management planning city wide. The City has also been addressing how existing hazards may be aggravated by climate change, including increases in the intensity of extreme precipitation, coastal flooding, and sea level rise. Hurricane Sandy demonstrated the vulnerability of the city to coastal flooding, and further study was required to understand how coastal flooding will interact with and potentially be worsened by urban flooding from rainfall. Also, drainage is projected to worsen in low-lying coastal areas as sea level rise increasingly blocks outfalls in tidal cycles and during surge events. Sea level rise maps have been developed by NYC Department of City Planning showing tidal inundation during mean high-high water events for the 2020s, 2050s, 2080s, and 2100. Many of these areas have been prioritized for coastal protection projects or drainage improvements, but even with implementation of these projects the inland areas will likely experience flooding through outfalls and inability to drain during high tides. Similarly, inland areas may experience more urban flooding increasing damage to public and private property. This study developed a full, citywide H&H model that can be used to identify priority at-risk areas in the city. The model was used to test multiple rainfall scenarios, including extreme and moderate events, with varied spatial distribution, intensity, frequency, and durations. The model was also used to investigate the impact of changing climate conditions on flood conditions and stormwater management practices, based on climate projections from the New York City Panel on Climate Change (NPCC). These impacts include changes in sea level, groundwater, storm frequency and intensity, and the intensity, duration, and frequency and duration of precipitation events. The study also looked at flooding from coincident surge and precipitation, and investigated geographically-specific stormwater conditions where flooding may be influenced by sea level rise, tidal inundation, and/or elevated groundwater. Results from these analyses were intended to be used to inform the City's current and future stormwater management practices and prioritize interventions. (Completed 2021—see https://www.nyc.gov/site/ddc/about/press-releases/2021/pr-062921-TG.page)

Making Waves: Uses of Real-Time, Hyperlocal Flood Sensor Data for Emergency Management, Resiliency Planning, and Flood Impact Mitigation

Andrea I. Silverman, Tega Brain, Brett Brancod, Praneeth saiF
venkat Challagonda, Petra Choi, Rebecca Fischman, Kathryn Graziano, Elizabeth Hénaff, Charlie Mydlarz, Paul Rothman, Ricardo Toledo-Crow

See below under New York University for abstract and article information.

Columbia University

Is an Epic Pluvial Masking the Water Insecurity of the Greater New York City Region?

Neil Pederson, Andrew R. Bell, Edward R. Cook, Upmanu Lall, Naresh Devineni, Richard Seager, Keith Eggleston, and Kevin P. Vranes

Six water emergencies have occurred since 1981 for the New York City (NYC) region despite the following: 1) its perhumid climate, 2) substantial conservation of water since 1979, and 3) meteorological data showing little severe or extreme drought since 1970. This study reconstructs 472 years of moisture availability for the NYC watershed to place these emergencies in long-term hydroclimatic context. Using nested reconstruction techniques, 32 tree-ring chronologies comprised of 12 species account for up to 66.2% of the average May–August Palmer drought severity index. Verification statistics indicate good statistical skill from 1531 to 2003. The use of multiple tree species, including rarely used species that can sometimes occur on mesic sites like *Liriodendron tulipifera*, *Betula lenta*, and *Carya spp.*, seems to aid reconstruction skill. Importantly, the reconstruction captures pluvial events in the instrumental record nearly as well as drought events and is significantly correlated to precipitation over much of the northeastern United States. While the mid-1960s drought is a severe drought in the context of the new reconstruction, the region experienced repeated droughts of similar intensity, but greater duration during the sixteenth and seventeenth centuries. The full record reveals a trend toward more pluvial conditions since ca. 1800 that is accentuated by an unprecedented 43-yr pluvial event that continues through 2011. In the context of the current pluvial, decreasing water usage, but increasing extra-urban pressures, it appears that the water supply system for the greater NYC region could be severely stressed if the current water boom shifts toward hydroclimatic regimes like the sixteenth and seventeenth centuries.

Journal of Climate, Vol. 26, Issue 4 (2013) (at https://journals.ametsoc.org/view/journals/clim/26/4/jcli-d-11-00723.1.xml)

The 1960s Drought and the Subsequent Shift to a Wetter Climate in the Catskill Mountains Region of the New York City Watershed

Richard Seager, Neil Pederson, Yochanan Kushnir, Jennifer Nakamura, and Stephanie Jurburg

The precipitation history over the last century in the Catskill Mountains region that supplies water to New York City is studied. A severe drought occurred in the early to mid-1960s followed by a wet period that continues. Interannual variability of precipitation in the region is related to patterns of atmospheric circulation variability in the midlatitude east Pacific–North America–west Atlantic sector with no link to the tropics. Associated SST variations in the Atlantic are consistent with being forced by the anomalous atmospheric flow rather than being causal. In winter and spring the 1960s drought was associated with a low pressure anomaly over the midlatitude North Atlantic Ocean and northerly subsiding flow over the greater Catskills region that would likely suppress precipitation. The cold SSTs offshore during the drought are consistent with atmospheric forcing of the ocean. The subsequent wet period was associated with high pressure anomalies over the Atlantic Ocean and ascending southerly flow over eastern North America favoring increased precipitation and a strengthening of the Northern Hemisphere storm track. Neither the drought nor the subsequent pluvial are simulated in sea surface temperature–forced atmosphere GCMs. The long-term wetting is also not simulated as a response to changes in radiative forcing by coupled models. It is concluded that past precipitation variability in the region, including the drought and pluvial, were most likely caused by internal atmospheric variability. Such events are unpredictable and a drought like the 1960s one could return while the long-term wetting trend need not continue—conclusions that have implications for management of New York City's water resources.

Journal of Climate, Vol. 25, Issue 19 (2012) (at https://journals.ametsoc.org/view/journals/clim/25/19/jcli-d-11-00518.1.xml)

Testing Homes for Potential Sources of Lead Exposure as a High-School Science Project

Evan M. Sefchick, Daniel Dusevic, Jack R. Dougherty, Andrew Terraciano, Tyler Ellis, Alexander van Geen

High-school students tested soil, paint, and water for lead (Pb) in a total of 80 houses in their town of Pelham, New York, where blood-Pb data indicate relatively high levels of child exposure. All the samples were tested in the laboratory using established procedures but this was preceded by testing of soil and paint in the field with a kit by the students. The total Pb concentration in 32 of the 159 soil samples that were collected exceeded 400 ppm, the EPA standard for bare soil in residential areas where children play. Only 4 of the 118 tap water samples that were collected contained over 15 ppb Pb, with the data showing that flushing for 2 min clearly lowered Pb concentration further across the board. The highest risk of child exposure may be posed by old Pb-based paint, however, which was detected in 9 of the 48 samples that were tested. Residents were also the least willing to let the students test or sample their paint. High-school students could help reduce exposure in the many towns where child blood-Pb levels remain high today by identifying sources and, while doing so, learn about environmental science and measurement from this hands-on experience.

GeoHeath, Vol. 5, Issue 11 (November 2021) (at https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021GH000498)

Did the COVID-19 Lockdown Impact New York Harbor's Water Quality?

Naomi Schulberg and Ajit Subramaniam

Waterways such as the Hudson River play an integral role in agriculture, health, transportation, recreation, energy, and sustaining biodiversity. Although water pollution in New York Harbor has been extensively studied, the reduction of millions of commuters during the COVID-19 lockdown presents an unprecedented opportunity to study human impact on water quality. The researchers used remote sensing data to assess how the COVID-19 lockdown impacted water quality in New York Harbor, particularly in areas near Combined Sewer Outfalls (CSOs). This technique has previously been used to measure water quality in the Hudson River. They used ACOLITE to process Landsat-8 and Sentinel-2 images from 2015-2020. The algorithms “t_nechad”, “spm_nechad”, and “kdpar_qaasw” were used to measure turbidity, and “chl_oc2”, “chl_oc3”, “chl_re_moses3b”, “chl_re_moses740”, and “chl_re_mishra” to measure chlorophyll concentration. After uploading processed images into SeaDAS, we extracted values from pixels corresponding to Department of Environmental Protection (DEP) field sites. At these sites, the DEP measures Total Suspended Solids and Chlorophyll A Concentration using optical turbidity sensors and fluorometers, respectively. By comparing pixel values with DEP data, the researchers determined that the chlorophyll algorithms did not produce accurate readings of chlorophyll concentration in New York Harbor. They focused on analyzing turbidity at five DEP sites, four of which were located around wastewater treatment plants, to assess any CSO-induced changes in water quality. The frequency of usable satellite data from 2020 was severely limited by cloudiness, so they combined Landsat-8 and Sentinel-2 turbidity measurements ($R = 0.8685$) to form time series for each site. The researchers expected to see a decrease in turbidity during the lockdown period, due to a decrease in sewage from office buildings. However, turbidity strongly fluctuated throughout all years with no discernable temporal pattern, and they could not distinguish between 2020 measurements and seasonal patterns. Thus, preliminary analysis shows that there was no significant variation in water turbidity due to the COVID-19 lockdown.

ESS Open Archive, January 15, 2021 (at https://essopenarchive.org/doi/full/10.1002/essoar.10505849.1)

Spatial Patterns of Pharmaceuticals and Wastewater Tracers in the Hudson River Estuary

Mark G. Cantwell, David R. Katz, Julia C. Sullivan, Daniel Shapley,
John Lipscomb, Jennifer Epstein, Andrew R. Juhl, Carol Knudson, Gregory D. O'Mullan

The widespread use of pharmaceuticals by human populations results in their sustained discharge to surface waters via wastewater treatment plants (WWTPs). In this study, 16 highly prescribed pharmaceuticals were quantified along a 250 km transect of the Hudson River Estuary and New York Harbor to describe their sources and spatial patterns. Sampling was conducted over two dry weather periods in May and July 2016, at 72 sites which included mid-channel and nearshore sites, as well as locations influenced by tributaries and WWTP outfalls. The detection frequency of the study pharmaceuticals was almost identical between the May and July sampling periods at 55% and 52%, respectively. Six pharmaceuticals were measurable at 92% or more of the sites during both sampling periods, illustrating their ubiquitous presence throughout the study area. Individual pharmaceutical concentrations were highly variable spatially, ranging from non-detect to 3810 ng/L during the study. Major factors controlling concentrations were proximity and magnitude of WWTP discharges, inputs from tributaries and tidal mixing. Two compounds, sucralose and caffeine, were evaluated as tracers to identify wastewater sources and assess pharmaceutical behavior. Sucralose was useful in identifying wastewater inputs to the river and concentrations showed excellent correlations with numerous pharmaceuticals in the study. Caffeine-sucralose ratios showed potential in identifying discharges of untreated wastewater occurring during a combined sewage overflow event. Many of the study pharmaceuticals were present throughout the Hudson River Estuary as a consequence of sustained wastewater discharge. Whereas some concentrations were above published effects levels, a more complete risk assessment is needed to understand the potential for ecological impacts due to pharmaceuticals in the Hudson River Estuary.

Water Research, Vol. 137 (2018) (at https://www.sciencedirect.com/science/article/pii/S0043135417310394)

Stochastic Downscaling of Hourly Precipitation Series from Climate Change Projections

Ziwen Yu , Franco Montalto, Stefan Jacobson, Upmanu Lall , Daniel Bader , and Radley Horton

See below under Drexel University for abstract and article information.

Cornell University

Power and Pathways: Exploring Robustness, Cooperative Stability, and Power Relationships in Regional Infrastructure Investment and Water Supply Management Portfolio Pathways

David F. Gold, Patrick M. Reed, David E. Gorelick, Gregory W. Characklis

Cooperation between urban water utilities can allow water managers to use existing water sources more efficiently and save money on future investments. Water utilities may cooperate by coordinating their responses to drought conditions or co-investing in new supply infrastructure. However, the design of cooperative water management strategies is a challenging task. Cooperative strategies must balance the potentially conflicting interests of all cooperating partners. If this balance is not done carefully, the benefits of cooperation are quickly negated by conflict between partners. This work contributes a new methodology for designing cooperative water management strategies that serve as sustainable compromises across a set of cooperating partners. We introduce a new set of tools that allows water managers to explore trade-offs between different cooperative strategies, highlight important vulnerabilities for each cooperating partner and illustrate how power relationships within the cooperative partnership can affect the performance of a cooperative strategy. We demonstrate our methodology on the Sedento Valley, a regional urban water supply test case where three water utilities seek to improve their performance through regional cooperation. Our results highlight the complex power relationships that exist between the three water utilities and suggest strategies to achieve sustainable regional cooperation.

Earth's Future, Vol. 10, Issue 2 (February 2022) (at https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2021EF002472)

Improving the Robustness of Reservoir Operations with Stochastic Dynamic Programming

Gi Joo Kim; Young-Oh Kim; and Patrick M. Reed

Reservoir operations should consider both adaptiveness and robustness to deal with two of the main characteristics of climate change: nonstationarity and deep uncertainty. In particular, robust operational strategies are distinguished from risk-neutral expected value optimization in the sense that they should be satisfactory over a wider range of uncertainty and improve the ability of a reservoir system to adapt to climate change. In this study, a new framework named robust stochastic dynamic programming (RSDP) is proposed that couples robust optimization (RO) with the formulations of objective function or constraints used in stochastic dynamic programming (SDP). Two main approaches of RO, namely feasibility robustness and solution robustness, are both considered in the optimization algorithm. Consequently, this study uses the Boryeong multipurpose dam to evaluate three SDP framings: conventional-SDP (CSDP), RSDP-feasibility robustness (RSDP-F), and RSDP-solution robustness (RSDP-S). These three SDP formulations were used to derive optimal monthly release rules for the Boryeong Dam, and their relative performances were evaluated using simulations of a broader range of inflow scenarios. The simulation-based re-evaluations of the resulting reservoir operational policies were quantified using a wide range of metrics that include reliability, resiliency, and vulnerability, as well as regret-based robustness metrics. The results of this study suggest that the RSDP-S model not only increases the range of possible solutions, but also yields more desirable operation outcomes under extreme climate conditions with respect to both traditional and robustness metrics.

Journal of Water Resources, Planning and Management, Vol. 147, Issue 7 (July 2021) (at https://ascelibrary.org/doi/10.1061/%28ASCE%29WR.1943-5452.0001381)

Fecal Indicator Bacteria, Fecal Source Tracking Markers, and Pathogens Detected in Two Hudson River Tributaries

Yolanda M. Brooks, Catherine M. Spirito, Justin S. Bae, Anna Hong, Emma M. Mosier, Desiree J. Sausele, Cristina P. Fernandez-Baca, Jennifer L. Epstein, Dan J. Shapley, Laura B. Goodman, Renee R. Anderson, Amy L. Glaser, Ruth E. Richardson

Volunteer monitoring in the Hudson River watershed since 2012 has identified that the Wallkill River and Rondout Creek tributary complex have elevated concentrations of the fecal indicator bacteria, enterococci. Concentrations of enterococci do not provide insight into the sources of pollution and are imperfect indicators of health risks. In 2017, the regular monthly volunteer monitoring campaign for culturable enterococci at 24 sites on the Wallkill and Rondout expanded to include: (1) culturable measurements of E. coli and quantification of E. coli and Enterococcus specific markers vis nanoscale qPCR, (2) microbial source tracking (MST) assays (avian, human, bovine, and equine) via real time PCR and nanoscale qPCR, and 3) quantification of 12 gastrointestinal pathogens including viruses, bacteria, and protozoa via nanoscale qPCR. Three human associated MST markers (HumM2, HF183, and B. theta) corroborated that human pollution was present in Rondout Creek and widespread in the Wallkill River. The presence of B. theta was associated with increased concentrations of culturable E. coli. Genes for adenovirus 40 and 41 conserved region, rotavirus A NSP3, E. coli eae and stx1, and Giardia lamblia 18S rRNA were detected in >45% of samples. Abundance of rotavirus A NSP3 genes was significantly correlated to the bovine marker gene, CowM3, though wild bird sources cannot be ruled out. This is the first study to investigate potential fecal pollution sources and pathogen concentrations in Hudson tributaries during the months of peak recreational use.

Water Research, Vol 171 (March 2020) (at https://www.sciencedirect.com/science/article/pii/S0043135419311169?via%3Dihub)

Retrofitting Municipal Wastewater Treatment Facilities toward a Greener and Circular Economy by Virtue of Resource Recovery: Techno-Economic Analysis and Life Cycle Assessment

Xueyu Tian, Ruth E. Richardson, Jefferson W. Tester, José L. Lozano, and Fengqi You

A promising route to transition wastewater treatment facilities (WWTFs) from energy-consuming to net energy-positive is to retrofit existing facilities with process modifications, residual biosolid upcycling, and effluent thermal energy recovery. This study assesses the economics and life cycle environmental impacts of three proposed retrofits of WWTFs that consider thermochemical conversion technologies, namely, hydrothermal liquefaction, slow pyrolysis, and fast pyrolysis, along with advanced bioreactors. The results are in turn compared to the reference design, showing the retrofitting design with hydrothermal liquefaction, and an up-flow anaerobic sludge blanket has the highest net present value (NPV) of $177.36MM over a 20-year plant lifetime despite 15% higher annual production costs than the reference design. According to the ReCiPe method, chlorination is identified as the major contributor for most impact categories in all cases. There are several uncertainties embedded in the techno-economic analysis and life cycle assessment, including the discount rate, capital investment, sewer rate, and prices of main products; among which, the price of biochar presents the widest variation from $50 to $1900/t. Sensitivity analyses reveal that the variation of discount rates causes the most significant changes in NPVs. The impact of the biochar price is more pronounced in the slow pyrolysis-based pathway compared to the fast pyrolysis since biochar is the main product of slow pyrolysis.

ACS Sustainable Chemistry & Engineering, Vol 8, Issue 36 (at https://pubs.acs.org/doi/10.1021/acssuschemeng.0c05189)

Rapid qPCR-Based Water Quality Monitoring in New York State Recreational Waters

Cristina P. Fernández-Baca, Catherine M. Spirito, Justin S. Bae, Zsofia M. Szegletes, Nathan Barott, Desiree J. Sausele, Yolanda M. Brooks, Daniel L. Weller and Ruth E. Richardson

Public swimming beaches often rely on culture-based methods to determine if fecal indicator bacteria (FIB) levels are greater than health risk-based beach action values (BAV). The slow turnaround time of culture-based assays can prevent effective beach closure and reopening decisions. Faster testing methods that can be completed on-site are needed. Additionally, beach closures are currently based on high FIB levels, but at-present there are no tools to examine the health risks to bathers from myriad pathogens (e.g., bacteria, viruses, protozoa) that may be present in recreational waters. Twelve New York State beaches (n = 9 freshwater and n = 3 marine) were monitored over the course of summer 2018, and two of the freshwater beaches were monitored in fall 2017 as part of a preliminary study. A rapid, in-field workflow for detecting fecal enterococci in water samples was tested using four assays on two Biomeme handheld devices. All Biomeme-based workflows involved in-field DNA extractions and qPCR using portable devices. Beach water samples were also analyzed using EPA-approved or EPA-based qPCR methods: two culture-based methods, Enterolert (targeting enterococci at freshwater and marine beaches) and Colilert (targeting E. coli at freshwater beaches); and one qPCR method based on EPA 1611.1. For low abundance pathogen quantification, nanoscale-qPCR was conducted in 2018 using the Pathogen Panel which targeted 12 viral, bacterial, and protozoal pathogens. In fall 2017, the qPCR-based methods performed similarly to Enterolert (r2 from 0.537 to 0.687) and correctly classified 62.5–75.0% of water samples for a BAV of 104 MPN per 100 ml. In summer 2018, the correlation between Enterococcus levels based on Biomeme qPCR and Enterolert varied substantially between the 12 beaches. Inclusion of diverse regions and beach types may have confounded the Biomeme qPCR results. The EPA 1611.1-based method showed a weak, significant correlation (r2 = 0.317, p = 0.00012) with Enterolert. Nanoscale-qPCR showed low-levels of pathogens present at all beach sites; but only three showed up with any substantial frequency, E. coli eae (25% of samples), norovirus (31.4%), and Giardia lamblia (11.4%). Preliminary studies to establish beach-specific correlation curves between rapid qPCR and Enterolert methods are needed before any qPCR assay is used to inform beach decisions.

Frontiers in Water, Vol.3 (October 2021) (at https://www.frontiersin.org/articles/10.3389/frwa.2021.711477/full)

Impact of Oxidation Processes on the Composition and Biodegradability of Soluble Organic Nutrients in Wastewater Effluents

Nicholas B. Tooker, Ce Gao, Annalisa Onnis-Hayden, April Z. Gu

The characteristics and bioavailability of wastewater derived organic nutrients and their susceptibility to removal technologies have implications in nutrient loading to aquatic environments and their contributions to eutrophication. Therefore, a better understanding of treatability of effluent organic nutrients is of interest for water resource recovery facilities (WRRFs) and regulators. Oxidation processes (OPs) can reduce concentrations of soluble organic nutrients and convert them into more biodegradable forms. In this study, three WRRF effluents were treated with low-pressure ultraviolet (UV) irradiation, hydrogen peroxide (H2O2), and combined UV/H2O2. Untreated and treated effluents were subjected to nitrogen and phosphorus speciation analyses and soluble organic nitrogen (SON) biodegradability assays. The OP treatments did not change SON concentrations significantly. For two WRRFs, OP treatments decreased soluble organic phosphorus (SOP) and seemed to convert it into soluble acid hydrolyzable phosphorus (SAHP), indicating possible increases in phosphorus bioavailability. Fingerprinting and quantification of dissolved organic matter (DOM) using fluorescence spectroscopy with parallel factor analysis revealed changes in DOM pool composition in response to OPs treatments, which suggests likely organic nutrients composition changes. Based on biodegradability assessments, OP treatments likely changed the composition and biodegradability of effluent SON compounds. Combined UV/H2O2 treatment seemed more effective than other OPs at oxidizing some of the organic nutrients.

Water Environmental Research, Vol. 93, Issue 2 (February 2021) (at https://onlinelibrary.wiley.com/doi/10.1002/wer.1393)

Drexel University

Characterizing Current and Future Extreme Heavy Rainfall in New York City, Task 3 of Climate Vulnerability, Impact and Adaptation Analysis (Town+Gown Master Contract RFP at https://www.nyc.gov/assets/ddc/downloads/town-and-gown/DCAS_MOCR_VIA_RFP.pdf)

Franco Montalto and Patrick Gurian

Climate change requires stormwater managers to rely on highly uncertain projections of future rainfall event, given that the past record may no longer apply to future conditions. Drexel researchers are working, as part of the Task 3 Team, to build flood resiliency and vulnerability reduction models, based on a detailed study of historical and future heavy rainfall characteristics across NYC and the NYC region, and develop an event ranking and historical trends analysis of observed rainfall events. Drexel researchers and researchers from Sarah Lawrence will convene a stormwater subcommittee composed of experts on how stormwater infrastructure is designed and operated to understand 1) the context in which projections of future rainfall events are used and 2) to identify how organizational processes can most effectively accommodate updated information on future rainfall events.

Observed Variability in Soil Moisture in Engineered Urban Green Infrastructure Systems and Linkages to Ecosystem Services

Bita Alizadehtazi, Patrick L. Gurian, Franco A. Montalto
Soil-water-climate-vegetation interactions jointly determine the ability of landscapes to provide ecosystem functions and services. In particular, spatio-temporal patterns in soil moisture underpin landscape ecohydrology. Though these patterns have been of interest to researchers for some time, there is new interest in the topic today as city managers engineer green infrastructure (GI) into urban landscapes. This paper presents soil moisture data collected from 2012 to 2014, and weighing lysimeter observations continuing through 2016, in two urban GI systems. Relationships between precipitation history, season, soil depth, hydraulic loading ratio (HLR) on the frequency and magnitude of soil moisture responses are described quantitatively. A logistic regression model is used to quantify the odds that each of these variables triggers a detectable soil moisture response. The results suggest that the higher HLR site (Site 2, HLR = .8) had 129.7% higher odds of a soil moisture response than Site 1 (HLR = 1). The results also indicate that there are 82.9% lower odds of a response in summer than in winter. Moreover, the odds of a response decrease with increasing soil depth. The linkage between GI siting and design decisions that impact soil moisture and ecosystem services is illustrated by also reporting evapotranspiration (ET) rates at the sites as determined by the lysimeter. Higher ET observed during wetter conditions supports the hypothesis that GI siting and design factors that lead to higher moisture content can engender greater ecosystem services associated with this hydrologic process. Indeed, the higher HLR of Site 2 sustained higher soil moisture levels during the summer compared to Site 1.

Journal of Hydrology, Vol. 590 (November 2020) (at www.elsevier.com/locate/jhydrol)

A Preliminary Assessment of Coastal GI's Role during Hurricane Sandy: A Case Study of Three Communities

Stephanie M. Wong , Patrick L. Gurian , Jad Daley , Holly Bostrom , Marc Matsil and Franco A. Montalto

New York City's coastlines are a mosaic of natural and man-made habitats intermixed with housing and industry, all of which are extremely vulnerable to flooding, storm surge, and damaging wave action. Risks are projected to increase over time as sea levels rise, population grows, and the frequency and severity of extreme events increase. This paper investigates the potential role of green infrastructure (GI) as a risk reduction measure, using Hurricane Sandy as a case study. Specifically, this research examines whether the type, size, and configuration of GI played a role in determining the odds of building damages. Results suggest that proximity to different GI types did affect the odds of damage, both positively and negatively, and that the impacts of both small-scale and large-scale natural features varied geographically. Results suggest that nature-based solutions to coastal flooding must be tailored to specific local conditions in order to be effective.

Urban Water Journal (2020) (at https://doi.org/10.1080/1573062X.2020.1781909)

Exploring the Long-Term Economic and Social Impact of Green Infrastructure in New York City

S. M. Wong and F. A. Montalto

Across the world, cities are spending billions of dollars to manage urban runoff through decentralized green infrastructure (GI). This research uses an agent‐based model to explore some of the physical, social, and economic consequences of one such urban GI programs. Using the Bronx, NY, as a case study, two alternative approaches to GI application are compared. The first (Model 1) mimics NYC's current GI program by opportunistically selecting sites for GI within the city's priority combined sewer watersheds; the second (Model 2) features a more spatially flexible approach to GI siting, in which the city attempts to maximize opportunities for co‐benefits within the geographic areas considered in Model 1. The effects of both approaches, measured in terms of stormwater captured and co‐benefits (e.g., carbon sequestered) provided, are tracked over 20‐year simulations. While both models suggest it will be difficult to meet the citywide stormwater capture goals (managing the first 2.5 cm of rainfall from 10% of impervious surfaces) in the Bronx solely through public investment in GI, Model 2 shows that by integrating GI with other city initiatives (e.g., sustainability goals and resilience planning), synergistic outcomes are possible. Specifically, Model 2 produces stormwater capture rates comparable to those obtained under Model 1, but these rates are accompanied by elevated co-benefits for Bronx communities. The results are discussed in the context of future GI policy development in NYC.

Water Resources Research, 56 (October 2020) (at https://doi.org/10.1029/2019WR027008)

Stochastic Downscaling of Hourly Precipitation Series from Climate Change Projections

Ziwen Yu , Franco Montalto, Stefan Jacobson, Upmanu Lall , Daniel Bader , and Radley Horton

Stochastic precipitation generators (SPGs) are often used to produce synthetic precipitation series for water resource management. Typically, an SPG assumes a stationary climate. We present an hourly precipitation generation algorithm for nonstationary conditions informed by the global climate model (GCM) forecasted average monthly temperature (AMT). The physical basis for precipitation formation is considered explicitly in the design of the algorithm using hourly pressure change events (PCE) to define the relationship between hourly precipitation and AMT. The algorithm consists of a multivariable Markov Chain and a moving window driven by time, temperature, and pressure change. We demonstrate the methodology by generating a 100-year, continuous, synthetic hourly precipitation time series using GCM AMT projections for the Northeast United States. When compared with historical observations, the synthetic results suggest that future precipitation in this region will be more variable, with more frequent mild events and fewer but intensified extremes, especially in warm seasons. The synthetic time series suggests that there will be less precipitation in the summers, while winters will be wetter, consistent with other research on climate change projections for the Northeast United States. This SPG provides physically plausible weather ensembles for water resource studies involving climate change.

Water Resources Research, Vol. 58, Issue 10 (November 2022) (at https://doi.org/10.1029/2022WR033140)

Fordham University

Water Quality of Urban Lakes in the New York City Region

John D. Wehr

Urban lakes are unique environments. Engineers, city planners, and conservationists all value these water bodies because they mitigate flooding, moderate local climate, support urban wildlife, and enhance the quality of life in urban centers. However, in megacities, lakes suffer from disconnection from their natural watershed. Instead, they receive stormwater from impervious surfaces, and experience biodiversity loss and degraded water quality, due to inputs of excessive nutrients, salts, and toxins. Fordham's laboratory has been studying water quality in urban lakes in the NYC region for several years, including lakes within Frederick Law

Olmsted's Central Park and Prosect Park. These urban lakes are greener than other lakes – but not in a good way. We have documented severe harmful algal blooms in several of NYC's lakes, waterbodies that millions of residents and visitors use for recreation and personal enjoyment. We have identified key factors that have led to the degradation of these important freshwater environments, conditions that could be corrected with a new vision of urban planning that embraces restoration of these unique systems.

Unpublished as of the date of this research inventory.

Manhattan College

Croton Water Filtration Plant Study for NYC Department of Environmental Protection (Town+Gown Master Contract RFP at https://www.nyc.gov/assets/ddc/downloads/town-and-gown/archived-rfps/Town+Gown%20RFP-Croton%20Water%20Filtration%20Plant%20Study.FINAL.pdf)

NYCDEP's Croton Water Filtration Plant (CFP) has been effective in maintaining compliance with current drinking water regulations since it was placed in operation in 2015. However, reservoirs in the Croton System have been impacted by the invasive species *Hydrilla* (currently treated with the aquatic herbicide fluridone), taste and odor causing chemicals such as geosmin, 2-methylisoborneol ("MIB") and cyanotoxins such as microcystin. In addition, perfluorinated compounds (PFCs) such as perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS) are concerning municipalities nationwide as a result of their persistence, mobility and toxicity. It is essential for NYCDEP to understand the effectiveness of current and alternate treatments for removing these and other contaminants as NYC expects to rely more heavily on the Croton System, particularly over the next five years with large infrastructure work underway for the Delaware System. This research evaluated the effectiveness of existing treatment options at CFP for removing taste and odor compounds (geosmin & MIB), PFCs (PFOA & PFOS), microcystin, fluridone, ProcellaCOR and manganese; evaluated alternative treatment options including chlorine dioxide (ClO_2) and UV with chlorine addition (UV/NaOCl); and determined whether greensand (MnO_2-coated sand) can be developed on existing coarse sand via chlorination of backwash water. Manhattan College performed an experimental bench-scale study were performed and analyzed the data obtained from the bench-scale treatability studies. (Completed December 2021)

Nitrogen Removal from Water Resource Recovery Facilities Using Partial Nitrification, Denitratation-anaerobic Ammonia Oxidation (PANDA)

Robert Sharp, Wendell Khunjar, Dennis Daly, Joshua Perez-Terrero, Kartik Chandran, Anthony Niemiec and Gregory Pace

Nitrogen removal from wastewater is an energy and chemical intensive process that is becoming increasingly more common around the world. To address the cost and complexity issues associated with biological nitrogen removal from wastewater, an alternative approach for achieving next generation nitrogen removal via partial nitrification, denitratation and anaerobic ammonia oxidation (PANDA) has been developed. The PANDA process relies on converting 50% of influent ammonia load to nitrate via aerobic ammonia (AerAOB) and nitrite oxidizing bacteria (NOB). The nitrate is reduced to nitrite (denitratation), followed by the removal of ammonia and nitrite by heterotrophic denitrifiers and anaerobic ammonia oxidizing biomass (AnAOB). Results from a pilot-scale sidestream PANDA demonstration at nitrogen loadings of 0.2–0.25 kg N/m^3-day illustrated that up to 80% ammonia removal could be achieved. Testing in the mainstream process at initial ammonia concentrations of ~25 mg N/L indicated that 90% removal of total inorganic nitrogen could be achieved and that nitrogen removal was ultimately dependent on operating factors including aeration time, supplemental carbon dosing, hydraulic retention time and nitrate concentrations. Results cumulatively indicated that there was inherent resiliency within the PANDA systems when responding to variable environmental and operational conditions. This is hypothesized to be due to the fact that nitrogen removal is due to the combined synergistic activity of AerAOB, NOB, heterotrophic denitrifiers and AnAOB. Accordingly, utilization of PANDA based treatment processes may allow Water Resource Recovery Facilities (WRRFs) to achieve more sustainable and cost effective nitrogen removal in sidestream and mainstream processes without the need for NOB suppression and complex operational controls.

Science of The Total Environment, Volume 724 (July 2020) (at https://www.sciencedirect.com/science/article/pii/S0048969720317964)

Power Plant Bromide Discharges and Potential Effects on DBP Formation

Jeanne M. VanBriesen, Adam T. Carpenter, Kelly D. Good, Chelsea Kolb, and Jessica M. Wilson

Power plant wastewaters contain bromide, and their discharge to the environment can increase bromide concentrations in surface waters used for potable water supply, increasing brominated disinfection byproducts in finished water. Drinking water utilities should assess upstream bromide sources to determine their contribution to bromide and brominated disinfection byproducts at drinking water intakes. Analysis of bromide sources and receiving water conditions helps in developing control strategies for bromide discharges that affect drinking water supplies.

JOURNAL American Water Works Association, Vol. 113, Issue 6 (July/August 2021) (at https://awwa.onlinelibrary.wiley.com/toc/15518833/2021/113/6)

Water Quality and Sustainability of the Hudson River Estuary

Kevin Farley and Jessica Wilson

The Hudson river, like other estuaries, throughout the world serves an important function as a transitional zone between inland freshwaters and the sea. The dominant features of the Hudson are closely tied to the geological origin of the river and to the physical forces that control the up-and-down motion of the water surface due to tides and the mixing of freshwater and saltwater regimes. Together, these processes have created a unique brackish water environment that includes a wide variety of habitat from tidal marshes to deep-water zones. Physical, chemical, and biological processes in the estuary work together to create a natural trap for sediments and a natural filter for nutrients. This latter effect is largely responsible for the high productivity of the estuarine ecosystem and helps to define the importance of the estuary as spawning and nursery grounds for major fish stocks in the region. The same physical, chemical, and biological attributes that make estuaries valuable and productive ecosystems have attracted large populations to their shores. In the process, estuaries and the urban landscape have become intertwined. Effects on water quality and biological resources have varied, with estuaries being very resilient to some human impacts, and yet very vulnerable to many others. The impacts of human development on the Hudson river serve as a good example of the past, present, and future challenges in managing our 'urbanized' estuaries. This chapter, therefore, begins with a description of the physical, chemical, and biological characteristics that contribute to the unique character of the Hudson river estuary. A summary of human development and its impact on water quality of the Hudson and its adjoining waters is then presented. This is followed by a discussion of efforts that have been enacted to improve water quality and programs that are being considered to restore or enhance the ecological function of the estuary. As part of this effort, attention is now being given to the potential effects of climate change. The overall aim of these programs is not to return the estuary to its preimpacted or natural state, but rather to create a sustainable environment that will support a rich and productive ecosystem while providing benefits to the surrounding human population.

In Ahuja S. (ed.) *Comprehensive Water Quality and Purification*, Vol. 4, pp. 106-119 (2014)

New York Institute of Technology

Spectrophotometry in PFOA Research

David Nadler

The degradation of the persistent compound perfluorooctanoic acid (PFOA) in water by ultraviolet light in the presence and absence of hydrogen peroxide was examined. A laboratory experiment was designed to answer the question: is UV spectrophotometry feasible for PFOA research? Spectrophotometry was able to measure the degradation of PFOA, but a very high concentration was required. The 1 mg/L used is very concentrated when compared to the 70 ng/L suggested level in drinking water. A UV/Visible diode array scanning spectrophotometer was used to measure changes in PFOA concentrations after 15-minute exposures to ultraviolet light and ultraviolet light with hydrogen peroxide. A noticeable drop in concentration was measured for a 1 mg/L sample. An argument in favor of utilizing UV spectrophotometry is made in PFOA research since chemical reactions between a substance and catalyst(s) regardless of concentrations. This is not intended to suggest UV-vis spectrophotometry for PFOA analysis in drinking water quality tests.

Unpublished as of the date of this research inventory.

New York University

Machine-Learning–Based Risk Assessment Method for Leak Detection and Geolocation in a Water Distribution System

Wilmer P. Cantos, Ilan Juran and Silvia Tinelli

Research Partners: EU Project Consortium of 22 Corporations; VITENS; W-SMART; University of Lille

Current leak detection practice in a water distribution system consists of monitoring the distributed volume in a district metering area (DMA) and the consumption measured with automated meter reading (AMR) at the building connections. The detection of the occurrence of a potential leak in a DMA is established through a systematic continuous comparison of the real-time distributed volume and the consumption for this DMA and/or, in the absence of AMR, the comparison of the monitored distributed volume and a reference curve based upon past monitoring records of the distributed volume under similar operational conditions. The purpose of this research was to develop, test, validate, and illustrate the application of the machine-learning–based risk assessment method for early detection of high likelihood leaks, their geolocation, and the detection accuracy assessment in the water distribution system of the demonstration site at the University of Lille, France. It illustrates that the proposed algorithm, integrated with a GIS-based spatial flow data analysis, efficiently supports early detection, likelihood severity assessment, and geolocation of leak sources. Robotic inspections are often expensive, and the authors' methods of a machine-learning (ML)–driven approach is an economical data-driven alternative for leak detection. With advanced supervisory control and data acquisition (SCADA) systems, real-time data sets of network hydraulic and water-quality parameters enable to provide water service operators with new tools for real-time leak detection in water distribution systems (WDS). The objective of this research was to develop and demonstrate the application of a machine-learning–based risk assessment method (ML-RAM), integrating a pattern recognition algorithm for mono- and multiparameter early leak detection with a GIS platform for temporal and spatial data analyses to support the geolocation of the source of leak and assess the likelihood of its occurrence.

Journal of Infrastructure Systems, Vol. 26, Issue 1 (2020) (at https://ascelibrary.org/doi/abs/10.1061/%28ASCE%29IS.1943-555X.0000517)

Demonstration of Sensing, Information and Communication Technology (SICT) Solutions for Smart Water Management: The Smart Water for Europe (SW4EU) Project

Eelco Trietsch, Renske Raaphorst, Silvia Tinelli and Ilan Juran

Research Partners: EU Project Consortium of 22 Corporations; VITENS; W-SMART; University of Lille, Suez, and Eau de Paris.

The Smart Water for Europe (SW4EU) EU-FP7 sponsored European Research Project was developed to contribute to the European Innovation Platform (EIP) Water by accelerating demonstration and thereby deployment of innovative smart water network technology solutions for upgrading the reliability, e!iciency, quality control, sustainability and resiliency of metropolitan drinking water supply services. Its outcome is expected to support significant improvements of the utility's capacity to respond to societal challenges and increasing public concerns, while enhancing European SME's competitiveness and e!ectively promoting economic growth in the emerging sector of Sensing, Information and Communication Technology (SICT) for smart water network applications. Furthermore, the project intent is to bring together the SICT industry experts and water operators to accelerate acceptance of innovations and accelerate their market penetration. The SW4EU Project objectives were to develop and demonstrate integrated smart water management solutions for water distribution networks across four demonstration sites (in the Netherlands, Spain, the United Kingdom and France). The water challenges addressed as part of this project include: water quality management (focused on early bio-contamination detection), leak detection and management, energy optimization and customer interaction, as those issues have been identified as the areas of greatest concern and interest for water distribution networks in Europe. These applications have been also selected due to their high potential for creating business cases of substantial savings and improvement of resource efficiency. It is expected that sharing the outcome of this case study will contribute to engage water utilities and policy makers in accelerating their deployment and thereby support the competitiveness of European SICT SMEs. The SW4EU Project was implemented across four demonstration sites in Europe, in the Netherlands, Spain, the United Kingdom and France. The demonstration project at the University of Lille demo-site involved the University of Lille, NYU, the W-SMART Association and the LIST Research Center of the French Commission of Atomic Energy. The project involved 22 partners who provided expertise and innovative technology solutions.

The Smart Water for Europe (SW4EU) Project (2019) (at https://drive.google.com/file/d/1aaewBajMQyoRQcU_rTl_whtg0_LfFZLr/view)

Artificial Intelligence-based Monitoring System of Water Quality Parameters for Early Detection of Non-specific Bio-contamination in Water Distribution Systems

Silvia Tinelli and Ilan Juran

Research Partners: EU Project Consortium of 22 Corporations; VITENS; W-SMART; University of Lille

This research aims to simulate bio-contamination risk propagation under real-life conditions in the water distribution system (WDS) of Lille University's Scientific City Campus (France), solving the source identification and the response modeling. Neglecting dynamic reactions and not considering the possible chemical decay of most of the contaminants leads to an overestimation of the exposed population. Therefore, unlike the available event detection models, this study considers the interrelated change of several water-quality parameters such as free chlorine concentration, pH, alkalinity, and total organic carbon (TOC) resulting from the pollutants blending. For this reason, the purpose of the research was to develop and demonstrate the feasibility of an artificial intelligence (AI)-based smart monitoring system that will effectively enable water operators to ensure a quasi real-time quality control for early chemical and/or bio-contamination detection and preemptive risk management. Advanced pattern recognizers, such as Support Vector Machines (SVMs), and innovative sensing technology solutions, such as Artificial Neural Network (ANN), have been used for this purpose, identifying the anomalies and the severity-level assessment. Vitens, the largest drinking water company of the Netherlands, allocated a designated part of their distribution network to be a demonstration network for online water quality monitoring. In recent years data-driven models such as Artificial Neural Networks (ANNs) have been successfully applied for water quality evaluation that focuses on modeling and prediction. The purpose of this research is to develop and demonstrate the feasibility of a smart monitoring of water-quality parameters for early bio-contamination detection, as well as the visualization of the detected anomalies on the network. It involved the development of statistical models and artificial intelligence (AI)-based algorithms to enable non-specific anomaly detection, referring to the pattern recognition previously defined and its geo-localization using GIS. The proposed algorithms are tested and compared with each other on the European WDS of the Lille Campus (north of France). The results show not only an efficient anomaly detection and risk-based classification, but also the ability to visualize the contaminated nodes on the network map, following a pre-established risk severity scale.

Water Supply, Vol. 19, Issue 6 (2019) (at https://iwaponline.com/ws/article/19/6/1785/66700/Artificial-intelligence-based-monitoring-system-of)

Smart Monitoring and Process Modelling of Wastewater Treatment in Paris (France)

M. Serrao, J. Bernier, V. Rocher, I. Juran, B. Tassin, P. Vanrolleghem

Research Partners: SIAAP; LEESU; W-SMART; ModelEAU, Laval University;

SIAAP is the public utility responsible for the management of wastewater as well as storm water in the Greater Paris region with 9 million inhabitants covering an area of 1 800 km2, as illustrated in figure 1. With the transport and treatment of nearly 2,5 million m3 of water per day of municipal and industrial wastewater (respectively 94% and 6% of dry weather flow), SIAAP plays an important role in the protection of public health and ecological status of the Seine and Marne rivers. It has been implementing a strategy that promotes the integration of smart systems for the control and management of operational processes. One of the principal objectives of this organizational-wide mobilization towards becoming a 'smart wastewater utility' is to improve the stability and reliability of the physical, biological and chemical processes required for treatment of water and sludge as well as the recovery of resources. In the last few decades, there have been experiences gained and lessons learned with the application of smart infrastructure in the sanitation sector (e.g. Ingildsen and Olsson, 2016). This is observed in particular in the fields of in-line monitoring of water flow and of qualitative process performance indicators used by automatic controllers (e.g. Sharma et al, 2011), as well as the development of computer aided mathematical models for simulation and scenario analysis (e.g. Benedetti et al., 2013). The hybridization of data analysis methods and intelligent forecasting modelling systems with process control is expected to provide many benefits. A digital twin model of a treatment plant can evaluate the status of a process, predict changes and prescribe mitigation actions to keep performance within norms and in compliance. Recent bibliometric analyses (e.g. Zhao et al., 2020) and reviews (e.g. Corominas et al., 2018) indicate the progression of academic studies applying an artificial intelligence-based data-driven approach to improve the reliability of wastewater systems, increase water quality and lower energy consumption. The purpose of the ongoing Ph.D. research project (2020 – 2023) within the SIAAP Mocopée framework, which is conducted in collaboration with the W-SMART Association, LEESU and modelEAU of the University of LAVAL, aims to develop a hybrid process control system that is based on knowledge of processes, but driven by data collection and interpretation. It aims to integrate the strengths of plant-wide simulation models to evaluate scenarios with the strength of data-driven AI models to recognize patterns and update the model parameters to maintain the alignment of the model with reality. It will integrate automatic data collection and quality control from high-frequency measurements from in-situ sensors and laboratory analyses (originating from LIMS and SCADA systems) to remove faulty readings and outliers and allow interpolation to replace missing data. These time series will then be uploaded to the dynamic process model to perform multiple simulation runs. This adaptive hybrid digital twin will make use of machine learning techniques to continuously check and update the model parameters characterizing physical, biological and chemical reactions happening during treatment processes. The digital twin will make use of data processing, modelling and data mining techniques to decide if adjustments of manipulated variables are recommended in the ongoing processes to maintain performance within thresholds. This digital twin model will be able to recognize type changes or anomalies in the operating conditions or parameter values of the plant model and follow in real-time the variable wastewater conditions in the different treatment stages, detect important changes early on, make predictions and suggest actions for mitigation to assure optimal treatment from the perspectives of water quality, economics and environmental protection, at minimal downtime. It could also be used for process design or upgrade and optimization by running different scenarios and evaluating the modeled outputs. The W-SMART Association has facilitated the cooperation with the NYU research team for this project.

Research report (2021) (at https://docs.google.com/document/d/1z3M2SwJGPNm1f4dzXuXLW_Fvadan3SVVlrpEQAtp0GM/edit)

Making Waves: Uses of Real-Time, Hyperlocal Flood Sensor Data for Emergency Management, Resiliency Planning, and Flood Impact Mitigation

Andrea I. Silverman, Tega Brain, Brett Brancod, Praneeth sai venkat Challagonda, Petra Choi, Rebecca Fischman, Kathryn Graziano, Elizabeth Hénaff, Charlie Mydlarz, Paul Rothman, Ricardo Toledo-Crow

Flooding is expected to increase due to intensification of extreme precipitation events, sea-level rise, and urbanization. Low-cost water level sensors have the ability to fill a critical data gap on the presence, depth, and duration of street-level floods by measuring flood profiles (i.e., flood stage hydrographs) in real-time with a time interval on the order of minutes. Hyperlocal flood data collected by low-cost sensors have many use cases for a variety of stakeholders including municipal agencies, community members, and researchers. Here we outline examples of potential uses of flood sensor data before, during, and after flood events, based on dialog with stakeholders in New York City. These uses include inputs to predictive flood models, generation of real-time flood alerts for community members and emergency response teams, storm recovery assistance and cataloging of storm impacts, and informing infrastructure design and investment for long-term flood resilience project planning.

Water Research, Vol. 220 (July 2022) (at https://www.sciencedirect.com/science/article/pii/S0043135422006017?via%3Dihub)

For the related real-time data visualization platform, see https://dataviz.floodnet.nyc/. In Fall 2022, FloodNet received a grant from the NYC Department of Environmental Protection to expand the sensor network across NYC over the next five years.

Monitoring SARS-CoV-2 in Wastewater during New York City's Second Wave of COVID-19: Sewershed-level Trends and Relationships to Publicly Available Clinical Testing Data

Catherine Hoar, Francoise Chauvin, Alexander Clare, Hope McGibbon, Esmeraldo Castro, Samantha Patinella, Dimitrios Katehis, John J. Dennehy, Monica Trujillo, Davida S. Smyth and Andrea I. Silverman

New York City's wastewater monitoring program tracked trends in sewershed-level SARS-CoV-2 loads starting in the fall of 2020, just before the start of the city's second wave of the COVID-19 outbreak. During a five-month study period, from November 8, 2020 to April 11, 2021, viral loads in influent wastewater from each of New York City's 14 wastewater treatment plants were measured and compared to new laboratory-confirmed COVID-19 cases for the populations in each corresponding sewershed, estimated from publicly available clinical testing data. We found significant positive correlations between viral loads in wastewater and new COVID-19 cases. The strength of the correlations varied depending on the sewershed, with Spearman's rank correlation coefficients ranging between 0.38 and 0.81 (mean = 0.55). Based on a linear regression analysis of a combined data set for New York City, we found that a 1 $\log_{10}$ change in the SARS-CoV-2 viral load in wastewater corresponded to a 0.6 $\log_{10}$ change in the number of new laboratory-confirmed COVID-19 cases per day in a sewershed. An estimated minimum detectable case rate between 2–8 cases per day/100 000 people was associated with the method limit of detection in wastewater. This work offers a preliminary assessment of the relationship between wastewater monitoring data and clinical testing data in New York City.

While routine monitoring and method optimization continue, information on the development of New York City's wastewater monitoring program may provide insights for similar wastewater-based epidemiology efforts in the future.

Environmental Science: Water Research & Technology, Issue 5 (2022) (at https://pubs.rsc.org/en/content/articlelanding/2022/EW/D1EW00747E)

Escherichia coli and Enterococcus spp. Indigenous to Wastewater Have Slower Free Chlorine Disinfection Rates than Their Laboratory-Cultured Counterparts

Mwanarusi H. Mwatondo and Andrea I. Silverman

Most published data on chlorine disinfection of bacteria are from experiments conducted using reference-strain bacteria cultured in a laboratory. However, indigenous environmental bacteria, such as those in wastewater, can be more resistant to disinfection than their laboratory-cultured counterparts. To investigate this phenomenon, we conducted controlled experiments to systematically quantify and compare free chlorine inactivation kinetics of laboratory-cultured Escherichia coli and Enterococcus faecalis to corresponding E. coli and enterococci sourced from wastewater, without confounding factors related to the sample matrix. To allow direct comparison between bacterial populations, dissolved and particulate constituents of the sample matrices that could influence disinfection kinetics were removed using sequential centrifugation steps prior to disinfection experiments. The first-order chlorine inactivation rate constants of laboratory-cultured E. coli (k = 18.6 L mg–1min–1) and E. faecalis (k = 12.7 L mg–1min–1) were over an order of magnitude greater than those of wastewater-sourced E. coli (k = 0.65 L mg–1min–1) and enterococci (k = 0.18 L mg–1min–1) in PBS. These results indicate that wastewater bacteria were less susceptible to free chlorine inactivation than corresponding laboratory-cultured bacteria. Results from control experiments suggest that the observed differences in disinfection rates were due to cell-related differences between the bacterial populations and not caused by matrix effects, aggregation, or purification procedures utilized.

Environmental Science & Technology Letters, Vol. 8, Issue 12 (November 2021) (at https://pubs.acs.org/doi/10.1021/acs.estlett.1c00732)

Pace University

Just Blue Enough?: Synergies and Tradeoffs related to Use and Management of New York City Waterfront Environments

Anne Toomey and Monica Palta

Urban waterfronts are experiencing a renaissance, as it is estimated that by 2030 more than 60 percent of the world's population will live in cities, the majority of which are in coastal or riparian regions. This research explores both the ecosystem services (ES), or benefits to human wellbeing, that urban waterfronts provide and the potential disservices (DS) that can be associated with waterfront use. Benefits can include both biophysical and social benefits, but exposure to pathogens due to polluted water or social conflict (e.g., gentrification) due to competing interests are also potential outcomes. Both ES and DS may be especially pronounced for communities experiencing high levels of economic deprivation, which is a common demographic associated with urban waterfronts in general and the New York City (NYC) waterfront in particular. Using a mixed-methods approach to conduct research at two NYC waterfront locations, the researchers assessed how ES and DS are experienced by different waterfront users and spatiotemporally distributed in relation to social, cultural, and ecological factors. The researchers used a social assessment methodology that included quantitative counts of human activities along the waterfront site, observation of signs of human use, and interviews with waterfront users. Their findings demonstrate a wide range of uses and perceptions as well as deep place attachments held by local users, which give insight into understanding how the meanings associated with these blue spaces have changed over time. Both waterways were heavily utilized by local residents, who reported cultural ES including recreation, socializing, and even spiritual and religious associations. Interestingly, despite major pollution issues, fishing was the third most documented activity at one of our research sites, where they found that perceptions of water quality, rather than water quality as measured by pathogen load, were correlated with one’s willingness to eat fish. In addition, as with coastal cities across the United States, several large infrastructure projects are underway at these waterfront sites, including a ferry landing and a privately- owned boathouse. While these projects may increase opportunities for some residents to access these waterfront spaces, many local users perceived them as "disrupting" existing social-ecological connections and values, and thus sought to resist these projects. This research contributes to a growing body of knowledge on uses and stewardship associated with urban waterfronts, thus informing how to improve current environmental governance strategies in coastal cities.

Presentation to Joint Annual Meeting of Ecological Society of America and Canadian Society for Ecology and Evolution (Montreal, August 14-19, 2022)

Innovating to Protect Drinking Water and Ensure Right-to-Know in the Era of Climate Change

John Cronin

Waterborne illnesses due to contamination of public drinking water supplies are endemic in the U.S. and have been for decades. Climate change will bring concomitant increases in precipitation, runoff, sea level rise, and compromised infrastructure with additional adverse health consequences for tens of millions of water consumers nationwide. Water treatment systems and source control of pollutants are essential but imperfect. When waterborne contaminants reach consumers' home taps, immediate detection and immediate notification should be the final line of defense. But neither are current practice or policy. Large-scale investments in the innovation of real-time water monitoring, notification and forecasting technologies that guarantee consumers the right-to-know the quality of their drinking water must be included in climate mitigation policy and planning, and incorporated into the goals of the White House Climate Task Force.

Unpublished as of the date of this research inventory.

Pratt Institute

Jamaica Bay Story

RAMP

Jamaica Bay in Brooklyn and Queens is a saline-to-brackish estuary fed by several creeks, with barrier islands and marshlands, that extends over 25,000 acres supporting a rich wildlife. including migratory species. The Bay and its surrounding areas have been shaped and re-shaped by man over time. Urban transformation began in the 20th century with a series of parks, parkways and other transportation infrastructure requiring dredging and filling that forever altered the original shoreline and challenged the balance between man-made and natural ecosystems. Previously publicly owned land surrounding the Bay had been sold to private developers. The surrounding four Community Districts reflect diverse cultures and housing typologies. Although the communities have little in common, the entire area is comprised of the same geomorphology and the unique landform is vulnerable to flooding even with tidal movements.

In 2014, a planning studio studied the area's conditions thoroughly and designed policy recommendations for communities on the Rockaways peninsula, and undergraduate architecture students addressed housing by exploring new forms of (off-the-grid) living on the water during times of normalcy and disaster. The lack of connectivity to public transportation inspired design, with Common Ground, of a rigorous waterway network connecting all the protected basins of the Jamaica Bay and a multipurpose building imbued with economic development potential, becoming the gateway to the amphibious development with the ability to transform into a disaster relief center for the community when necessary. In 2015, based on a long-term relationship with RISE Rockaway, students envisioned how to contribute to the economic development of this community through pop up markets and street vendors. In 2019, the Delta Cities Coastal Resilience team, with RISE Rockaway, developed design strategies in response to environmental stresses from Superstorm Sandy, envisioning flood and stormwater protection measures, identifying socio-economic opportunities, and creating spaces where innovative programs can unfold. In 2020, graduate students, focusing on the entire Jamaica Bay area, and undergraduate students, focusing on specific locations within the area, worked with a consortium of local organizations and an expert team of advisors, developed strategies to address ecological, environmental and social aspects in addition to economic stability and patterns of human habitation and migration. In 2021, a graduate studio aimed at raising awareness of the possibility or the inevitability of managed retreat. The area's transportation network is thin and vulnerable, and daily commuting is challenging during the best of circumstances. In this setting, the studio proposed amphibious housing to weather the future storms and leveraging existing marinas and creating new ones to serve as a transportation gateway to the surrounding urban fabric. (at https://ramp-pratt.org/story_page/)

Fluid Frontiers, Towards a Unified Red Hook Sewershed

RAMP

Fluid Frontiers, a RAMP initiative report, demonstrated how urban planning can mitigate the risk that combined sewer outfalls (CSOs) poses to the health of New Yorkers and NYC's surrounding waterways and help NYC achieve the goals of the Clean Water Act. The research team used publicly available data, community input, and GIS mapping to quantify the amount of stormwater that cannot be handled by existing infrastructure within the Red Hook sewer shed during extreme wet weather events and identified strategically impactful locations where alternative water management strategies could be implemented to capture the amount of stormwater that current infrastructure cannot not handle (at https://drive.google.com/file/d/1R-az637AG4-qUfl8i2W8wKbWG7_d4aCi/view).

The Recovery, Adaptation, Mitigation, and Planning (RAMP) initiative was created by the Pratt Center for Community Development in 2012 after Superstorm Sandy (and Hurricane Irene) signaled the urgency to address resilience on the ground. RAMP is now an ongoing project of Pratt's Graduate Center for Planning and the Environment (GCPE) and the School of Architecture (SOA), which offers an interdisciplinary learning and creation platform to explore the *interrelationship among social equity, the environment, climate change and design and permits designers, policymakers, and environmentalists to collaborate with front-line waterfront communities to co-create and accelerate values-based, equitable, innovative, and effective strategies to recover, adapt, mitigate, and plan for the impacts of the climate crisis. RAMP, embedded into Pratt Institute's different academic programs through their curriculum and studio class projects, brings together faculty and students across disciplines as partners with marginalized communities working on the frontlines of climate change and community resilience. Professional planning expertise is paired with frontline empirical experience, with input from the scientific and engineering communities, to find solutions to the threats from rising sea levels, groundwater elevations, extreme rain, storm surge events, inland flooding, extreme heat, and habitat loss. Each semester, interdisciplinary faculty and student teams work with local community leaders, as equal partners in knowledge creation, to develop participatory design solutions to address the environmental and social pressures, document them, and share them broadly for potential replication and as a strategy for influencing public policy. RAMP fosters longer-term relationships that go beyond the academic calendar, leaving community partners with shared knowledge, , skills, data, and tools. RAMP is now at Pratt's Research Accelerator in Brooklyn Navy Yard (https://www.pratt.edu/news/idc-foundation-awards-million-grant-for-pratt-research-accelerator-hub/).*

State University of New York (Stony Brook University)

Experimental Study of Bed Evolution around a Non-slender Square Structure under Combined Solitary Wave and Steady Current Actions

Erdine Sogut, Deniz Velioglu Sogut, and Ali Farhadzadeh

This paper presents the findings from the laboratory wave flume experiments designed to investigate the formation and evolution of scour around a non-slender, square vertical structure, under three flow conditions, solitary wave, combined solitary wave and steady following current, and combined solitary wave and steady opposing current. The structure was placed on a sandy berm, either fastened to the flume wall or positioned at the centerline of the flume. For the wave only case, the scour on the seaside edge turned out to be deeper than the one on the leeside regardless of the structure's position. The analyses showed that the depth, width, volume, and location of the scour were all significantly influenced by the introduction of steady currents. The following current, for example, deepened the seaside scour, while leading to shallower leeside scour holes as a result of the backfilling process. Contrary to the opposing current, which shifted the scour area in the upwave direction, the scour was transported downwave under the effect of the following current. The scour depth was determined to be a function of the structure position and the Keulegan-Carpenter number, whereas the scour width mostly depended on the structure's position. In this regard, the structure fastened to the wall experienced the widest scour area and the largest volume regardless of the flow condition.

Ocean Engineering, Vol. 266, Part 2 (December 2022) (at https://doi.org/10.1016/j.oceaneng.2022.112792)

SCC-CIVIC-PG Track A: Human-centric, Data-driven Coastal Flood Resilience Strategies for Economically Disadvantaged Communities on Long Island, National Science Foundation 10/1/22 – 3/31/23

A. Farhadzadeh (Lead PI), R. Kline (SBU); D. Finn (SBU) and F, Ortega (CUNY).

This Civic Innovation Challenge (CIVIC) research has a focus of developing a community-centric, hybrid modeling approach for coastal flooding mitigation planning. Combining state-of-the-art, high-resolution flood modeling with community engagement, the development of optimal mitigation strategies that are informed by the needs of the community, as they define them, will be enabled. By expanding the scope of the factors considered in the modeling process, its realism will be improved, enhancing the planning capacity of, and the buy-in from, the local community. In close collaboration with a Long Island, New York coastal community and the Suffolk County planning department, community stakeholders will be engaged in collecting and generating data on key socio-economic characteristics and behavioral propensities of the community. Employing a suite of social scientific techniques, these data will be used to predict the social and behavioral responses to extreme flooding events and potential policy interventions. The predicted responses will be fed back into the model to enable a more holistic assessment of the mitigation strategies. The project will provide residents, policymakers, and other stakeholders with powerful new tools to both better assess the impact of future extreme events and determine the optimal adaptation and mitigation strategies. This inclusive modeling approach can be applied to other communities, tailoring optimal engineering solutions to their needs and as a result, enhancing the equity and effectiveness of engineering solutions and municipal planning for flood mitigation and adaptation. The novelty of this project is its community-centric simulation-based approach for assessing risks to infrastructure, properties, and local businesses on coastal flood plains due to extreme weather events. Specifically, this project will develop a physics-informed community-scale high-fidelity computer model for quantitative assessment of these risks and will implement mitigation strategies informed by the model that have been co-produced with the local community, considering the implications for local businesses. In addition to traditional inundation-depth information, the project will enhance the current flood prediction capabilities by including other flood-related factors such as erosion and damage to infrastructure. The robust process of engaging with the local community and decision makers, used to refine and parameterize the model to better address the needs of the community and consider their behavioral responses, will help further the goals of environmental justice and socioeconomic equity. Such an approach is unique and innovative. It has the potential to save substantial costs while improving the quality of life for the ~40 percent of the nation's total population who live in coastal counties.

Collaborative Research: Hybrid Flow-Sediment-Structure Interaction Analysis of Extreme Scour due to Coastal Flooding, National Science Foundation Project 1/1/2022 – 12/31/2024

Ali Farhadzadeh (Lead PI), Tian-Jian Hsu (Co-PI, UD), and Majid Ghayoomi (Co-PI, UNH),.

Foundation scour is one of the primary causes of structural damage in coastal communities during flooding events. This project will leverage state-of-the-art in wave flume physical modeling, geotechnical centrifuge modeling, and numerical simulation to answer a number of critical and open questions related to the interactions among extreme flood flow, soil, and structure which lead to scour and foundation failure—shifting the paradigm in the current understanding of key physical processes in flood-induced scouring process in complex urban setting. Enhancement of open-source multi-physics computational tool for coastal hazard mitigation will provide a strong multi-disciplinary modeling platform to the broader civil and coastal engineering research community. The new parameterization set for extreme scour-liquefaction resulted from the fundamental knowledge-gain will benefit region-scale nearshore morphodynamic modeling and the state of foundation design in flood-prone areas. The education and outreach efforts will broaden the participation at all levels including: (1) recruitment, retention, and education of underrepresented students in three collaborating institutions; (2) engaging science teachers in three coastal states with different urban settings and population, in coastal infrastructure and community resiliency training; and (3) enhancing the well-being of the coastal residents through changing the design and hazard mitigation protocols. This project will bridge the state-of-the-art in sediment transport and scour, unsaturated and saturated soil mechanics, and hydrodynamics of flood flow. This goal will be achieved by correlating the spatiotemporal variations of scouring and loading with the dynamics of shallow flood flows within complex urban setting and water hysteresis in unsaturated soils around and underneath surface structures. The research objectives of this project are to understand: (1) scouring patterns of single and array of structures, under various flow and soil states; (2) initiation and progression of foundation scouring in low fines content soils of varying properties (i.e., composition, relative density, initial water content); (3) soil-foundation interaction response under simultaneous wave action and hydraulically-induced excess pore pressure; (4) rocking response of shallow foundations in unsaturated ground; (5) enhancement of an open-source Eulerian two-phase modeling framework for a complete description of seabed stability and scour; and (6) incorporating an extended effective stress-based sub-model and a revised solver for slight water compressibility to simulate soil behavior in partially drained and unsaturated condition with high overburden. The long-term goal of this project is to create public-domain tools for reliable scour predictions of complex urban and non-urban settings, under extreme coastal flooding conditions.

EAGER: SAI: Collaborative Research: Behavioral Theories for Resilient and Sustainable Infrastructure, National Science Foundation Project 9/1/2021- 8/31/2023

Elizabeth Hewitt (PI, SBU), Ali Farhadzadeh (Co-PI), and Majid Ghayoomi (Co-PI, UNH). Strengthening American Infrastructure (SAI) is an NSF Program seeking to stimulate human-centered fundamental and potentially transformative research that strengthens America's infrastructure. Effective infrastructure provides a strong foundation for socioeconomic vitality and broad quality of life improvement. Strong, reliable, and effective infrastructure spurs private-sector innovation, grows the economy, creates jobs, makes public-sector service provision more efficient, strengthens communities, promotes equal opportunity, protects the natural environment, enhances national security, and fuels American leadership. To achieve these goals requires expertise from across the science and engineering disciplines. SAI focuses on how knowledge of human reasoning and decision making, governance, and social and cultural processes enables the building and maintenance of effective infrastructure that improves lives and society and builds on advances in technology and engineering. This SAI project investigates interactions between the human decision-making process and infrastructure performance. Human actions and the decisions made in planning, designing and constructing infrastructure are influenced by an engineer's socioeconomic and demographic characteristics, attitudes, values, and perceptions. Infrastructure response is also driven by uncertainties in material properties, design strategies, and physical and climatic stressors. This project links a well-studied social science framework (The Theory of Planned Behavior) to engineering modeling, offering new and transformative knowledge about infrastructure management. The new research models are specifically tested in the context of resilient flood protection systems such as levees and breakwaters in flood-prone communities. The project aims to advance social science theory, develop new metrics for measuring and predicting the interaction of social, economic, and physical behavior of infrastructure components, and to use these metrics to enhance the resilience of infrastructure. The project ultimately helps to connect engineers with tools and methods that enable them to better understand and consider human behavior, potentially leading to tangible physical outputs. This will improve infrastructure design and performance assessment, making infrastructure safer, more cost-effective, and resilient. This project focuses primarily on theory building to develop a dynamic and novel model merging the Theory of Planned Behavior (TPB) and System Dynamics

Modeling. The goal is to integrate important social science variables such as values, norms, and attitudes into the flow of decision making an engineer undertakes for infrastructure design and uncertainties associated with infrastructure performance. The project develops a refined theoretical framework merging TPB with engineering, including a systematic theory-driven literature review, interviews with experts, and a survey of the engineering community. This static model is then transitioned to a more dynamic system platform incorporating dependencies, sensitivity analyses, and multivariate statistics. Bridging the theory to practice is tested on two flood defense target infrastructure systems (levees and breakwaters) in flood-prone communities. The anticipated outcomes of the research include advancing social science theory, developing new metrics for measuring and predicting the interaction of social, economic, and physical behavior of infrastructure components, and using these metrics to enhance the resilience of infrastructure in design, construction, performance, and maintenance phases. The project builds a transdisciplinary new theory by extending a widely studied behavioral framework to strengthen convergence between social science and infrastructure. Ultimately, the project will help to connect engineers with tools and methods that enable better understanding of human processes that intervene in the performance of urban infrastructure.

Collaborative Research: Collaborative Research: Damage Assessment of Coastal Structures Subject to Waterborne Debris Impact under Extreme Wind and Wave Conditions,
National Science Foundation Project 9/1/2022-8/31/2025

A. Farhadzadeh (Co-PI, SBU), H. Waisman (Lead PI, Columbia) and H. Tang (Co-PI, CUNY),.

With rising sea-levels and more frequent weather-related extreme events, coastal civil infrastructure and communities are becoming more flood-prone and consequently subject to an elevated risk of damage and destruction. Among the various flood-related risks, flood-borne debris can be destructive to coastal infrastructure (e.g., buildings, houses, and bridges). Such debris (e.g. trees, cars, and ships) are carried by floods and waves, often in combination with extreme wind gusts. Currently, there is a significant gap in understanding and modeling the key physical processes associated with flood-borne debris. This project will provide a science-based approach to understand and predict the flood-borne debris damages to structures under extreme flood flow and wind conditions. The research will also be complemented by an educational component that includes workshops, curriculum development, and training demonstrations. The educational program will be designed to have positive and measurable impact on a broad spectrum of students (ranging from high school to graduate students), foster an increased participation among minority and underrepresented groups, and inform students of the novel research and diverse cultures of the three participating institutions, i.e., Columbia

University, SUNY at Stony Brook, and CUNY City College. This award will contribute to the National Science Foundation (NSF) role in the National Windstorm Impact Reduction Program (NWIRP). The overarching goal of this research is to understand and quantify the critical mechanics processes involved in water-wind-debris-structure interactions, including debris drifting by extreme flow and wind conditions, debris collision with the structure, and the resulting damages. A multidisciplinary approach employing computational fluid dynamics, computational solid mechanics, and laboratory experiments will be used to achieve this goal. Specific research tasks include: (1) innovative experiments deploying “smart debris” to investigate wind and transport effects of flood-borne debris and their impact/damage to structures, (2) new computational methods and software for an integrated simulation of debris drifting, impingement, and damage to structures, and (3) novel physics-based fragility curves, at the system level, for structural failure risk assessment due to debris impacts. In the long term, this research can lead to enhanced designs and mitigation strategies for structures susceptible to the impact of flood and debris, advancing the well-being of the public through development of resilient coastlines and communities.

The New School

Integrated Assessment of Urban Water Supply Security and Resilience: Towards a Streamlined Approach

Elisabeth H Krueger, Timon McPhearson and Simon A Levin

Urbanization and competing water demand, as well as rising temperatures and changing weather patterns, are manifesting as gradual processes that increasingly challenge urban water supply security. Cities are also threatened by acute risks arising at the intersection of aging infrastructure, entrenched institutions, and the increasing occurrence of extreme weather events. To better understand these multi-layered, interacting challenges of providing urban water supply for all, while being prepared to deal with recurring shocks, we present an integrated analysis of water supply security in New York City and its resilience to acute shocks and chronic disturbances. The researchers apply a revised version of a recently developed, quantitative framework (‘Capital Portfolio Approach’, CPA) that takes a social-ecological-technological systems perspective to assess urban water supply security as the performance of water services at the household scale. Using the parameters of the CPA as input, they use a coupled systems dynamics model to investigate the dynamics of services in response to shocks—under current conditions and in a scenario of increasing shock occurrence and a loss of system robustness. The researchers find water supply security to be high and current response to shocks to be resilient thanks to past shock experiences. However, they identify a number of risks and vulnerability issues that, if unaddressed, might significantly impact the city’s water services in the mid-term future. These findings have relevance to cities around the world, and raise questions for research about how security and resilience can and should be maintained in the future.

Environmental Research Letters, Vol. 7, No. 7 (July 2022) (at https://iopscience.iop.org/article/10.1088/1748-9326/ac78f4)

The Value of Urban Flood Modeling

B. R. Rosenzweig, P. Herreros Cantis, Y. Kim, A. Cohn, K. Grove, J. Brock, J. Yesuf, P. Mistry, C. Welty, T. McPhearson, J. Sauer, H. Chang

Floods are important disturbances to urban socio-eco-technical systems and their meteorological drivers are projected to increase through the century due to global climate change. Urban flood models are numerical models that have the capability of representing the features of urban ecosystems and the mechanisms of flooding that impact them. They have the potential to play a critical role in flood risk assessment, operational response, and resilience planning, but existing models remain limited in their capability to represent integrated flooding processes in urban areas and provide the credible quantitative information needed to support risk assessment and resilience practice. Research to advance model development, facilitate intensive watershed monitoring for model parameterization and validation, and support collaboration between researchers and practitioners should be prioritized. This will represent a substantial, expensive effort, but will still be of great value as cities are faced with urgent challenges posed by climate change in coming decades.

Earth's Future, Vol. 9, Issue 1 (January 2021) (at https://doi.org/10.1029/2020EF001739P

Shifting Landscapes of Coastal Flood Risk: Environmental (In)justice of Urban Change, Sea Level Rise, and Differential Vulnerability in New York City

Pablo Herreros-Cantis, Veronica Olivotto, Zbigniew J. Grabowski and Timon McPhearson

Climate-driven changes in coastal flood risk have enormous consequences for coastal cities. These risks intersect with unequal patterns of environmental hazards exacerbating differential vulnerability of climate related flooding. Here we analyze differential vulnerability of coastal flooding in New York City, USA, as an environmental justice issue caused by shifts in flood risk due to increasing floodplain extents. These extents are represented by updates to the 100-year floodplain by the Federal Emergency Management Agency, and urban changes in land use, land value, and socio-economic characteristics of flood exposed populations. The researchers focus on six local community districts containing disproportionately vulnerable communities. Across the study areas, they observed increases in the floodplain's extent by 45.7%, total exposed population by 10.5%, and population living in vulnerable communities by 7.5%. Overall flood risk increases regardless of increases in the updated floodplain extent, as do floodplain property values. However, variability is high between community districts; in some cases, increases in exposure coincide with decreases in vulnerability due to shifts in racial demographics and increases in income (i.e. potential floodplain gentrification), while others experienced increases in exposure and vulnerability (i.e. double jeopardy). These findings highlight that the dominant drivers of coastal flood risk in NYC are ongoing real estate development and continued increases in sea level rise and storm severity, both of which have explicit implications for flood vulnerability. The researchers describe the social processes governing development in the flood zone, namely zoning, resilience planning, and the determination of potential flooding severity and related insurance rates. They also discuss how these social drivers of risk intersect with social dimensions of vulnerability due to racist housing markets, and the distributions of public housing and toxic chemical hazards. They conclude with a framework for the analysis of contextual and outcome-based vulnerability to coastal flood hazards, and provide policy recommendations to reduce risks over the medium to long term.

Urban Transformations 2:9 (at https://doi.org/10.1186/s42854-020-00014-w)

Assessment of Urban Flood Vulnerability Using the Social-Ecological-Technological Systems Framework in Six US Cities

Heejun Chang, Arun Pallathadka, Jason Sauer, Nancy B. Grimm,
Rae Zimmerman, Chingwen Cheng, David M. Iwaniec, Yeowon Kim,
Robert Lloyd, Timon McPhearson, Bernice Rosenzweig, Tiffany Troxler,
Claire Welty, Ryan Brenner, Pablo Herreros-Cantis

As urban populations continue to grow through the 21st century, more people are projected to be at risk of exposure to climate change-induced extreme events. To investigate the complexity of urban floods, this study applied an interlinked social-ecological-technological systems (SETS) vulnerability framework by developing an urban flood vulnerability index for six US cities. Indicators were selected to reflect and illustrate exposure, sensitivity, and adaptive capacity to flooding for each of the three domains of SETS. The researchers quantified 18 indicators and normalized them by the cities' 500-yr floodplain area at the census block group level. Clusters of flood vulnerable areas were identified differently by each SETS domain, and some areas were vulnerable to floods in more than one domain. Results are provided to support decision-making for reducing risks to flooding, by considering social, ecological, and technological vulnerability as well as hotspots where multiple sources of vulnerability coexist. The spatially explicit urban SETS flood vulnerability framework can be transferred to other regions facing challenging urban floods and other types of environmental hazards. Mapping SETS flood vulnerability helps to reveal intersections of complex SETS interactions and inform policy-making for building more resilient cities in the face of extreme events and climate change impacts.

Sustainable Cities and Society, 68, 102786 (at https://www.sciencedirect.com/science/article/pii/S2210670721000780)