

## Abdul Latif Jameel World Water and Food Security Lab

How do we secure society's fundamental resources—water and food—and how do we sustain the ecosystems that provide them, while the human population rapidly grows, urbanization increases, and the Earth is altered by climate change?

These questions drive the work of the [Abdul Latif Jameel World Water and Food Security Lab \(J-WAFS\)](#), established in 2014 at MIT through a generous gift from alumnus Mohammed Jameel '78. J-WAFS is an Institute-wide effort to bring MIT's unique strengths to bear on safeguarding the world's supplies of water and food and improving the accessibility and sustainability of water and food systems. The J-WAFS mission (updated in fiscal year 2018) is to catalyze MIT's contributions in research, innovation, and technology for ensuring safe and resilient supplies of water and food while reducing environmental effects. Both are needed to meet the local and global needs of a rapidly expanding and evolving population on a changing planet.

In pursuit of this mission, J-WAFS works across all MIT departments, laboratories, and centers (DLCs) to leverage MIT's research activities and world-class scholarship and facilities for solutions-oriented research in water and food systems. J-WAFS staff do this through a variety of programs and strategies by:

- making research and commercialization grants, both large and small, that fuel existing work in water and food and bring new faculty and students to work on challenges in these sectors;
- supporting events and outreach efforts across and beyond the Institute that raise the profile of MIT as a stimulating space for water and food innovators who seek to address critical challenges; and
- supplying student support and mentorship in the form of graduate fellowships, travel awards, and personal engagement with staff and funded faculty members.

### Supported Research

#### Seed and Solutions Grant Program

Seven new seed grants were awarded in fiscal year 2018 following a competitive application process, representing \$1.3 million in research funding awarded to MIT principal investigators (PIs). The research community funded by J-WAFS seed funds and solutions grants include:

- 57 PIs representing 19 MIT DLCs from all five schools
- 58 students (including doctoral degree candidates, master's degree candidates, visiting students, and undergraduates)
- 35 postdoctoral associates
- 15 additional research staff (research scientists, assistants, and administrators)

Since the launch of both grant programs in 2015, 130 seed and solutions grant proposals have been submitted by 125 different MIT PIs, representing 31 DLCs, including the Whitehead Institute and one subaward to the Harvard Medical School. Results of these funding include:

- \$8 million and growing in follow-on funding received by MIT researchers
- 5 US patent applications
- 3 licensing agreements
- 2 spinout companies
  - Via Separations, which came out of Professor Jeffrey Grossman's laboratory
  - a company yet to be named, launched by Professor Timothy Swager's laboratory
- 1 spinout company currently in development by Professor T. Alan Hatton's laboratory
- Numerous presentations at high-profile meetings and conferences, as well as news coverage by numerous international online and print news outlets
- Multiple publications in top journals and a number of MIT theses

### **Research Affiliate Program**

The J-WAFS three-year Research Affiliate agreement with Xylem, Inc., is supporting three sponsored research projects. By the close of FY2018, all three sponsored research projects will have been launched. The three projects are based in the Laboratory for Information and Decision Systems and the Department of Mechanical Engineering (MechE). Additional support found in the Research Affiliate agreement includes financial sponsorship of the MIT Water Club, three J-WAFS one-year graduate student fellowships, the J-WAFS Water Leaders Travel Grant, and mentorship of MIT teams competing for the Water Innovation Prize.

### **Student Engagement and Support**

In addition to the Research Affiliate graduate student fellowship, J-WAFS awards the Rasikbhai L. Meswani Fellowship for Water Solutions from an endowed gift that provides one semester of funding to advanced MIT PhD students. Through these fellowship programs, J-WAFS has committed funds for a total of five one-semester fellowships to students from the Department of Biological Engineering (BE); the Institute for Data, Systems, and Society (IDSS); MechE; and the Department of Urban Studies and Planning (DUSP).

Two additional grants provided further research and travel funding to MIT students this year: Grant for Water and Food Projects in India and J-WAFS Water Leaders Travel Grant.

In addition to co-sponsoring the MIT Water Club and the MIT Food and Agriculture Club, J-WAFS has continued to provide mentorship to the leaders of both groups. This has included:

- Advice for programing of their signature events such as the Water Summit, Water Night, and the business plan competitions that are run by both clubs
- Introductions between water and food sector professionals and club members
- Amplification of club events and opportunities through our monthly email newsletter
- Providing opportunities for in-person networking between students in these groups and relevant professionals external to MIT

## External Engagement

### Fundraising and International Partnerships

In October 2017, a delegation from the Indian Institute of Technology Ropar (IIT Ropar), led by Director Professor Sarit K. Das, met at MIT with J-WAFS senior leadership and a broad group of MIT faculty and program leaders. This preliminary discussion led to a proposal for a partnership between IIT Ropar and MIT J-WAFS that would facilitate test-bedding MIT projects relevant to Indian food and water systems and opportunities for student exchange. MIT faculty visited IIT Ropar during the summer of 2018 to continue this discussion.

A gift from MIT alumnus Kishore Mariwala SM '59 is supporting the new J-WAFS Grant for Water and Food Projects in India. Mariwala has committed funds for a second round of grants on the basis of satisfactory progress on projects funded by the grant in FY2018.

The Rabobank Group continues to support MIT students and student-led innovations in the food sector through the Rabobank-MIT Food and Agribusiness Innovation Prize. The competition was held for the third time in 2018.

### Honing the Message

In FY2018, facilitated by the addition of the communications and program manager position in late FY2017, J-WAFS augmented its communications and outreach to support its fundraising efforts as well as its overall visibility. Central to these efforts was a decision to change the J-WAFS name from the Abdul Latif Jameel World Water and Food Security Lab to the Abdul Latif Jameel Water and Food Systems Lab, with a tagline that captures the J-WAFS mission and goals: Securing humankind's vital resources. The new name and tagline will be made public in mid-September 2018.

J-WAFS created a suite of public-facing media and materials, including a new mission statement, to showcase its programs and achievements more effectively and to support fundraising efforts. This effort included a redesign of the monthly newsletter. J-WAFS also embarked on a website redesign project that is slated for completion in January 2019. The goal of this project is to provide more space on the website to document J-WAFS-funded projects and showcase the achievements of the program and the PIs J-WAFS funds. In collaboration with Abdul Latif Jameel and Community Jameel, J-WAFS has attracted significant worldwide press coverage, especially in the Middle East and North Africa region.

## Events

An important way in which J-WAFS builds the community of MIT researchers focused on water and food systems topics is through events. Some of these initiatives—such as the Seed Grant Research Workshop and the research speed-dating event—bring the MIT research community together to exchange research and workshop project ideas; others—such as the water innovation prize, as well as the food and agribusiness innovation prize—provide entrepreneurship and related leadership opportunities to MIT students; and still others—like the expert workshop on “Climate Change, Agriculture, Water, and Food Security: What We Know and Don’t Know”—bring experts from around the world to tackle critical global challenges. Details about these and other events produced in FY2018 are included in the “Engagement” section of this report.

## Grantmaking

Two major grant programs constitute the core of J-WAFS research support for the MIT community: J-WAFS seed grant program and J-WAFS Solutions program. Both conducted a fourth round of funding in FY2018. Two additional funding streams supporting water and food sector research are also continuing in FY2018: the graduate student fellowship program and sponsored research projects supported by the Research Affiliate program. This year, J-WAFS expanded its funding for MIT water and food sector research by introducing two new grant opportunities: J-WAFS Grant for Water and Food Projects in India and J-WAFS Water Leaders Travel Grant.

## J-WAFS Seed Grants

### FY2018 Seed Grant Process and Awards

In November 2017, J-WAFS distributed the fourth annual request for proposals (RFP) for J-WAFS seed grants. These competitive two-year grants provide up to \$100,000 per year of research support, overhead-free, to MIT faculty members and other PIs. The mission of the program is to fund projects across the Institute that bring MIT’s strengths to bear on the varied and complex challenges that water and food systems face across the globe, prioritizing projects that are poised to have significant impact. Seed grants have supported junior faculty and PIs who are new to water and food sector research, influencing faculty research directions and enlarging MIT’s water and food research portfolio and associated impact.

Leading up to the issuance of the RFP, J-WAFS held its fourth annual research speed-dating event to promote exchange of ideas and spark new research collaborations. The RFP attracted submissions from 54 PIs—nearly twice that of FY2017—of whom 38 were new proposers to J-WAFS. A peer review process involving more than 100 faculty and research associates from across the Institute resulted in the selection of seven new projects led by 11 PIs across six MIT departments. The projects, which will begin on September 1, 2018, are from the departments of Chemical Engineering (ChemE); Civil and Environmental Engineering (CEE); Earth, Atmospheric and Planetary Sciences (EAPS); Electrical Engineering and Computer Sciences (EECS); Materials Science and Engineering (DMSE); and MechE.

The projects are:

- Novel Systems Biology Tools for Improving Crop Tolerance to Abiotic Stressors  
PIs: David Des Marais, associate professor, CEE, and Caroline Uhler, Henry L. and Grace Doherty Associate Professor, EECS and IDSS
- Assessing Climate Vulnerability of West African Food Security Using Remote Sensing  
PI: Dara Entekhabi, Bacardi and Stockholm Water Foundations Professor, CEE
- Printed Silk-Based Colorimetric Sensors for Food Spoilage Prevention and Supply Chain Authentication  
PIs: A. John Hart, associate professor in MechE, and Benedetto Marelli, Paul M. Cook Career Development Professor, CEE
- What Controls Arsenic Contamination in South Asia? Making Sense of Two Decades of Disjointed Data  
PI: Charles Harvey, professor, CEE
- Supermolecular Nanostructure Gels for Chelation of Arsenic from Drinking Water  
PI: Julia Ortony, Finmeccanica Career Development Professor, DMSE
- Anthropogenic Soils of the Amazon: Origins, Extent, and Implications for Sustainable Tropical Agriculture  
PIs: Dorothy Hosler, Professor of Archaeology and Ancient Technology, DMSE; P Heather Lechtman, Professor of Archaeology and Ancient Technology, DMSE; and J. Taylor Perron, associate department head and professor, EAPS
- Purifying Water from Boron Contamination with Highly Selective Metal-Organic Framework Membranes  
PI: Zachary Smith, Joseph R. Mares Career Development Professor, ChemE

### **FY2018: Concluding Seed Grant Projects and Milestones**

Another milestone of FY2018 was the conclusion of projects supported by the first round of two-year seed grants, awarded in 2015. Most of these funded projects ended in September 2017, successfully meeting the research objectives. Several exceeded expectations with new discoveries, publications in influential journals, and substantial follow-on funding awards. A small number of projects are continuing with no-cost extensions of their grants.

### ***Advancing Water and Food Sustainability Through Improved Understanding of Uncertainties in Climate Change and Climate Variability***

PIs: Susan Solomon, Lee and Geraldine Martin Professor of Environmental Studies, EAPS and Department of Chemistry (Chemistry); Kenneth Strzepek, research scientist, MIT Joint Program on the Science and Policy of Global Change

This project entailed the development of an agricultural model that estimates crop productivity and its response to water, soil quality, and temperature stressors. The research team used temperature, precipitation, and crop production data, representing 122 possible climate futures, to estimate more accurately climate impacts on future crop yields across Africa. They focused on maize, which is the most calorically important crop in sub-Saharan Africa, as well as the most widely produced. They have recently applied the model to project regional climate impacts on wheat, sorghum, cotton, sugarcane,

fruits and vegetables, roots and tubers, legumes, and groundnuts. The research results have already been influential on stakeholders working on infrastructure development in Africa. Two notable findings are that there are regions in Africa where the uncertainty of future climate is extreme, and others where there is significant agreement among climate projections; and that models suggest sufficient stream flow even under future climate conditions, which demonstrates that irrigation may be a viable adaptation strategy to support agricultural production throughout sub-Saharan Africa. Because infrastructure projects in Africa should be designed in the context of potential risks of climate change, the results of this research are extremely pertinent. The information that these crop models provide will ideally inform the design of future infrastructure projects and related investment decisions.

### ***A Data-Driven Approach to Managing Food Security in Global Supply Chains***

PIs: Retsef Levi, Spencer Standish (1945) Professor of Management, professor, Sloan School of Management (Sloan); Tauhid Zaman, assistant professor, Sloan; and Yanchong Zheng, associate professor, Sloan

The PIs focused their research on two global food supply chains: farming supply chains that connect farmers with food manufacturers, and shipping supply chains that connect food manufacturers to consumer markets. They set out to identify both qualitative and quantitative food safety risk metrics for farming and shipping food and, with those, produced models that can identify and predict where and how food safety risks occur in supply chains. Their work has demonstrated that these predictive models can capture the influence of quality control practices on companies' food safety risk profiles on the basis of their farming and shipping supply chain structures. The team has developed practical recommendations for improving the effectiveness of regulatory practices and plans to share these with stakeholders and policymakers in the US and China. This foundational work has garnered a tremendous amount of support; the team has received nearly \$8 million in follow-on funding to build an expanded food safety research program focusing on agricultural supply chains in China and is expanding the work to India.

### ***Electrochemically Modulated Separation Processes for the Treatment of Contaminated Water Sources***

PI: T. Alan Hatton, Ralph Landau Professor of Chemical Engineering Practice, ChemE

A 2015 J-WAFS seed grant supported the development of a new device that can be used for wastewater treatment. The system uses a novel electrochemical process that can selectively remove organic contaminants from water, among them pesticides, herbicides, heavy metals, radioactive materials, and contaminants of emerging concern such as pharmaceutical by-products. In the device, water flows between chemically treated surfaces (redox electrodes) that can be positively or negatively charged, a process that can remove individual contaminants at even parts-per-million concentrations. This energy-efficient water treatment process has the potential to serve as an eco-friendly alternative to conventional water treatment methods. The researchers are testing ways to run it using solar energy in order to make it available to rural regions in developing countries that are not connected to an energy grid. The research successes of Professor Hatton and his team have led to innovation prizes, papers published in professional journals, and a patent, as well as follow-on funding in the form of a 2016 J-WAFS Solutions grant.

### ***Enabling Distributed Water Quality Management by Dry Sample Preservation and Centralized Analysis***

PIs: Rohit Karnik, associate professor, MechE; John Hart, associate professor, MechE; and Chintan Vaishnav, senior lecturer, Sloan

This interdisciplinary research team applied engineering and system management approaches to better understand and support water quality monitoring systems in India from local laboratory to government levels, in particular in Maharashtra, Karnataka, and Gujarat states. The goal was to evaluate existing practices to determine how their new water sample preservation and analysis technologies could improve water quality measurement and water safety. The team focused on two objectives: engineering a method for dry sample preservation for water contaminants that are costly and logistically challenging for local laboratories to measure (heavy metals, pesticides, and so on); and developing tools to enable integrated water management practices that are informed by data. In addition to working in the laboratory, the research process has involved extensive outreach to policy makers in India at various levels of government and also to nongovernmental organizations. The team has received follow-on funding from the MIT Tata Center to extend the project, including support for its work with the Pollution Control Board in the state of Maharashtra and government officials tasked with water quality and sanitation monitoring, as well as technical consulting groups and other stakeholders.

### ***Engineered Nitrogen Fixation: Expression in Plant Organelles***

PI: Christopher Voigt, professor, BE

Professor Voigt and his laboratory used biotechnology to tackle some of the major technical challenges in bringing the nitrogen-fixing capabilities of legumes to cereal grains. Added nitrogen fertilizer is required for high agricultural productivity. Cereal grains capable of fixing atmospheric nitrogen could lessen the global need for synthetically derived nitrogen fertilizer that is energy intensive and expensive for many smallholder farmers in the Global South; it can also contaminate local water supplies through runoff. This goal is complex and requires a long time for completion. The 2015 J-WAFS two-year seed grant provided critical support, enabling the achievement of significant milestones. The researchers built a nitrogen-fixing gene pathway using chemical DNA synthesis and demonstrated that integration of a large, multigene cluster into the chloroplast genome is achievable. They initiated international collaborations with world leaders in the biochemistry of microbial nitrogen fixation, chloroplast biotechnology, and cell-free synthetic biology. These collaborations are proving critical to the project's progress. Professor Voigt has disseminated early research results through published journal articles and lectures at high-profile conferences and industry meetings. The project was granted follow-on funding in the form of a second 2017 J-WAFS seed grant that will support the next stage of this work.

### ***Quantifying Mercury Contamination of Rice and Its Impact on Food Security in China***

PIs: Noelle Selin, associate professor, IDSS and EAPS; and Valerie Karplus, assistant professor, Sloan

This project used models to understand better how mercury contamination occurs in rice grown in China and to identify the specific environmental and anthropogenic factors that exacerbate the contamination. They examined mercury sources and the biogeochemical processes that lead to rice contamination and evaluated the socioeconomic and public health costs of mercury contamination. The PIs' goal is to use their research results to demonstrate the need for policy changes to key decision makers in the region. The research team used models to simulate present-day atmospheric mercury deposition in order to show that regions where rice production is high are co-located with regions of high atmospheric mercury deposition. They compared this with the effects on rice of recently introduced mercury from atmospheric and irrigation sources. The study revealed that addressing the problem of mercury contamination in China requires both attention to contaminated soil and the regulation of anthropogenic mercury emissions. The team has already had the opportunity to disseminate its research at conferences and invited lectures, and will continue this line of research in collaboration with the MIT Joint Program on the Science and Policy of Global Change.

### ***Strategies for Urban Stormwater Wetlands: Los Angeles, CA and Houston, TX***

PIs: Alan Berger, Leventhal Professor of Advanced Urbanism, DUSP; and Heidi Nepf, Donald and Martha Harleman Professor and Margaret MacVicar Fellow, CEE

This multidisciplinary research team applied fluid dynamics and landscape architecture methodologies to develop design scenarios for constructed wetlands for urban settings. These designs maximize the capacity for urban wetlands to provide stormwater filtration, flood management, and enhanced biodiversity. Among their major outcomes were wetland designs with precise topographies that maximize stormwater filtration and that can be built at lower cost than conventional wetland designs; integration of a habitat diversity index to inform designs and improve biodiversity and ecological function; and designs that incorporate recreational use and demonstrate service to the public good. The researchers' geographic focus was on the US cities of Los Angeles, CA, and Houston, TX, and included meetings with policy makers in Los Angeles as part of their research. The resulting design framework was published in March 2018, and distributed—with a corresponding policy memo—to 125 policy makers, educators, and other stakeholders throughout the US. It is also freely available online.

### **Continuing Seed Grant Projects**

- Active Materials for Heavy Metal Extraction from Water  
PI: Timothy Swager, John D. MacArthur Professor, Chemistry
- Air Pollution Impacts on Global Crop Yields  
PI: Colette Heald, associate professor and associate department head, CEE
- Bacterial Viruses as Pathogen Control Agents in Aquaculture Systems  
PI: Martin Polz, professor, CEE
- Estimating the Benefits to Strengthening Water Markets  
PI: Christopher Knittel, George P. Shultz Professor, Sloan
- Gravity Fingering During Water Infiltration in Soil: Impact on the Resilience of Crops and Vegetation in Water-Stressed Ecosystems  
PI: Ruben Juanes, associate professor, CEE



- Real-time, On-site Detection of Foodborne Pathogens by Engineered Bacteriophage Integrated with Microfluidic Sample Preparation Platforms  
PIs: Jongyoon Han, professor, EECS and BE, and Timothy Lu, associate professor, EECS and BE
- Waste to Food: *Yarrowia lipolytica* as Protein and Lipid Production Platform  
PI: Gregory Stephanopoulos, Willard Henry Dow Professor of Biotechnology and Chemical Engineering, ChemE

### 2015 Seed Grants with No-cost Extensions

The original abstracts for these projects were reported in the 2015 annual report. Because of the no-cost extensions granted to each, the final outcomes will be reported in 2018.

- Leverage Points: Opportunities for Increasing Food Production in Developing Countries  
PIs: Dennis McLaughlin, King Bhumipol Professor, CEE; and Erica James, associate professor of medical anthropology and urban studies and director, MIT Global Health and Medical Humanities Initiative
- A Bioassay-Based Approach to Food Safety in China  
PIs: Anthony Sinskey, professor, Biology; Stacy Springs, senior director of programs, Center for Biomedical Innovation; and Vishal Vaidya, associate professor, Harvard Medical School

### J-WAFS Solutions Grants

In January 2018, with the support of the MIT Deshpande Center for Technological Innovation, J-WAFS distributed its fourth annual RFP for J-WAFS Solutions grants. This grant program, which is funded through a sponsored research grant from Community Jameel and administered in partnership with the Deshpande Center, has the mission of moving water and food technologies from the laboratories at MIT into the commercial world, where they will improve the productivity, accessibility, and sustainability of the world's water and food systems. Through the program, annual grants of up to \$150,000 are available to research teams that meet the program's requirements for readiness for commercialization. The J-WAFS Solutions program is also providing direct financial support to the Deshpande Center to support its administrative staff.

From its inception through FY2018, the Solutions program has funded nine projects, three of which received renewal grants. One Solutions-funded project resulted in a previously reported spin-off company. Another spin-off company that is focused on the deployment of a novel food safety sensor has been launched by the laboratory of Professor Swager. Yet another project—a low-cost water filter made of tree xylem being developed by a team with members from MechE and MIT's D-Lab—plans to make their designs open source once they are complete.

Solutions projects funded for FY2018 began in September 2017. The three new JWAFS Solutions projects are:

- In situ Particle Characterization in Emulsions for Field-scale Quality Assurance in the Dairy Industry  
PI: Sanjay Sarma, vice president for open learning and the Fred Fort Flowers (1941) and Daniel Fort Flowers (1941) Professor, MechE
- Reducing Runoff and Environmental Impact of Agricultural Sprays  
PI: Kripa Varanasi, associate professor, MechE
- Developing Intelligent Selective Electrodialysis for 21st-Century Agriculture  
PI: John H. Lienhard V, Abdul Latif Jameel Professor of Water and Food, MechE, and director, J-WAFS

The two renewed projects, which received a second year of funding, are:

- Development of Low-Cost Water Filter Using Sapwood Xylem  
PIs: Rohit Karnik, associate professor, MechE; and Amy Smith, senior lecturer, MechE, and founding director, MIT D-Lab
- Detection of Pathogens Using Dynamically Reconfigurable Liquid Colloid Particles  
PIs: Timothy Swager, professor, Chemistry; and Alexander M. Klibanov, Novartis Professor of Chemistry and Bioengineering, Chemistry and BE

### **Solutions Grant Project That Concluded in August 2017**

#### ***Floating, Heat Localizing Solar Receivers for Distributed Desalination***

PI: Gang Chen, Carl Richard Soderberg Professor in Power Engineering and department head, MechE

Funded in 2016, this project aimed to provide a scalable, low-cost floating solar desalination technology to meet the increasing demand for fresh water by small and distributed populations that do not have the technology or financial means to use the more resource-intensive reverse osmosis and multistage flash desalination technologies. This work continues to be a component of Chen's research portfolio. The team aims to further develop the technology by increasing its efficiency and water yield, and to adapt it for use in other applications, such as wastewater treatment and evaporation ponds. They are currently applying for further research funding from agencies such as the US Department of Energy and are looking for entrepreneurs to build a company around the technology that they have developed. The team reported that its participation in the J-WAFS Solutions program brought important exposure of the project to people at and beyond MIT who are now invested in the project.

#### ***Electrochemically Mediated Adsorptive Processes for Water Remediation***

PI: T. Alan Hatton, professor, ChemE

To address the need for efficient, affordable, and robust purification technologies, the Hatton research group developed an electrochemically assisted, chemically tunable, highly selective, and inexpensive platform technology that exploits nanostructured electrodes to selectively remove harmful contaminants at the nano- to micro-pollutant level, modulated solely by electrical potential and with no need for chemical regenerants.

This technology could be applied to a range of separation contexts, from point-of-source treatment or remote in situ purification devices to large-scale, centralized wastewater treatment facilities. During the term of the J-WAFS Solutions grant, the team designed and constructed a small-scale flow cell for demonstration, improved the materials chemistry and robustness of the electrodes, and targeted practical wastewater conditions.

The work continues within the Hatton group to finalize the testing of the current flow device and scale up the system to a multielectrode device, to get closer to commercialization; decrease chemical costs of electrode manufacturing and further improve robustness; and, through engagement with customers and outreach, collaborate with industry to tailor the technology and narrow the market application, including high-value added products and upstream purification. The research team is currently in the process of launching a spin-off company.

The January 2018 J-WAFS Solutions program's RFP brought new proposals. Funding decisions for 2019 will be announced in August 2018.

### **J-WAFS Research Affiliates Program**

In FY2018, Xylem, Inc., continued as an active and engaged member of the J-WAFS Research Affiliate program. As the inaugural J-WAFS Research Affiliate, this leading global water technology company—with operations in more than 150 countries—is partnering with three MIT faculty members selected by Xylem to conduct sponsored research projects that address specific water sector technology challenges. In addition to funding research, Xylem is actively engaged in student support, including financial sponsorship of the MIT Water Club (a one-semester J-WAFS graduate student fellowship offered each of the three years of the agreement), sponsorship of the J-WAFS Water Leaders Travel Grant, and mentorship of individual MIT students as well as MIT teams competing for the Water Innovation Prize.

Two out of three sponsored research projects were launched in 2017. In December, a third PI committed to a project that began on February 1, 2018. Xylem is very happy with the research progress and the close relationship this program has facilitated for Xylem with J-WAFS and MIT.

### **J-WAFS Graduate Student Fellowships**

In FY2017, J-WAFS awarded its first graduate student fellowships. Three outstanding graduate students are pursuing research in water with one semester of funding each. The two fellowships are the Rasikbhai L. Meswani Fellowship for Water Solutions and the J-WAFS Graduate Student Fellowship—funded by Xylem, Inc., through the research affiliates program.

### **J-WAFS Fellows**

The selected three students and their projects were previously reported on. Two of the students—Sarah Fletcher, PhD candidate at IDSS, and Tzu-Chieh (Zijay) Tang, PhD candidate in BE—completed their funded semester in FY2018. Omar Labban, PhD candidate in MechE, deferred his funding to FY2019.

## **Fellowship Selection and Awards**

During FY2018, two additional students were selected for AY2019 fellowship awards; one “honorable mention” recipient was also selected. The three students receiving recognition are:

- **Krithika Ramchander**—PhD candidate in MechE and past co-president of the MIT Water Club.  
She is a Rasikbhai L. Meswani Fellow for Water Solutions. The focus of Ramchander’s research is to develop a low-cost water filter using sapwood xylem from coniferous trees to facilitate safe access to drinking water for rural communities that lack access to safe water supplies. This project has also been supported by two J-WAFS Solutions grants.
- **Andrea Karin Beck**—PhD candidate in DUSP.  
Beck will be an AY2019 J-WAFS graduate student fellow and is examining how transnational water operators’ partnerships could provide an alternative approach for strengthening public water and sanitation utilities in developing countries.
- **Julia Sokol**—PhD candidate in MechE.  
Sokol was recognized with an “honorable mention” for her work in developing a novel design for drip irrigation emitters that operate at lower pressures and are more clog-resistant than currently available products.

## **J-WAFS Grant for Water and Food Projects in India**

In fall 2017, J-WAFS announced a new grant opportunity for shovel-ready MIT projects that focus on water and food challenges in India. This grant opportunity, made possible by a donation from MIT alumnus Kishore Mariwala SM ’59, was open to anyone in the MIT community. A multidisciplinary committee reviewed the proposals.

The 2018 grant award winners were two projects that each received \$15,000 grants. They were launched in January 2018 and will continue through January 2019.

### ***Scaling a Decentralized Biomass Torrefaction Reactor for Localized Fertilizer Production that Improves Farmers’ Yields and Reduces Irrigation Needs***

Project team: Kevin Kung, postdoctoral associate, MechE; Alex Slocum, professor, MechE; and Ahmed Ghoniem, professor, MechE

Project description: Currently, most of the world’s fertilizers are produced in capital- and energy-intensive centralized facilities in North America, Europe, and China. As a result, rural farmers in the Global South often pay two to three times the cost of fertilizer elsewhere. This JWAFS grant supported the launch of a pilot project in Maharashtra, India, which brings portable, low-cost reactor units that convert post-harvest agricultural residues into organic fertilizer using torrefaction. Torrefaction heats agricultural residues (husks, stalks, and other organic materials that are otherwise considered waste) under conditions that turn this biomass into an alkaline carbon-rich substance which, when added to soils, promotes plant growth and increases nutrient and water retention.

### **Conservation Credits for Groundwater Management**

Project Team: Ariel Zucker, PhD candidate, Department of Economics, and Nick Hagerty, PhD candidate, Department of Economics

Project Description: In India, groundwater is the source of 85% of drinking water and more than 60% of water for irrigation. However, this has resulted in over-extraction that poses a challenge to current and future agricultural production. New strategies for water management are needed to conserve these scarce resources while also increasing food production. This JWAFS grant is supporting an experimental study conducted in partnership with the Jameel Poverty Action Lab South Asia to compare the use of conservation credits with the existing practice of providing micro-irrigation investment subsidies. The team hopes to discover whether conservation credits can more effectively improve water resource management among farmers in rural India.

### **J-WAFS Water Leaders Travel Grant**

The J-WAFS Water Leaders Travel Grant was introduced in the spring of FY2018 with support from Xylem, Inc.. This grant opportunity offers travel grants to two MIT graduate students to attend one of two major water sector conferences in the summer of 2018: Singapore International Water Week or Stockholm World Water Week. Applicants chose between these conferences and submitted faculty references demonstrating how the conferences would positively influence their research, careers, or both.

Two students—Tiziana Smith, a PhD candidate in CEE, and Haleemah Qureshi MCP '18—were selected to receive funding to attend Stockholm World Water Week, a week-long international convening of academics, professional staff from nongovernmental organizations and industry, and government officials, with a 2018 theme of Water, Ecosystems, and Human Development.

Smith has plans for a career in sustainable water management policy and hopes to develop policies that balance the needs of people and ecosystems. Her current MIT research is to develop a methodology that quantifies potential sustainable food production in China under water and land resource constraints. Qureshi received a master's degree in city planning from DUSP where she developed expertise in water affordability and urban utilities through her study of the causes of US water shutoffs and the financing and funding structures for water utilities.

### **Engagement with the MIT Community**

In addition to providing funding for research support across all schools at MIT, J-WAFS is invested in cultivating the water and food systems research community at the Institute. This involves producing, co-producing, and co-sponsoring on-campus events as well as providing mentorship to students and student groups.

### **J-WAFS Events**

#### **J-WAFS Seed Grant Research Workshop, September 2017**

Principal investigators from three J-WAFS seed grant cycles presented updates on their work at this annual, daylong J-WAFS research workshop. Students, postdoctoral

associates, and professors attended the presentations of 22 funded research projects, including nine that had recently reached completion of their two-year grants. The day also included a lunchtime poster session featuring the 2015 and 2016 J-WAFS Solutions projects.

The Seed Grant Research Workshop has two goals: to nurture the water and food research community on campus and to provide a venue for seed grant PIs to present their research goals and progress and get feedback from faculty peers. Nearly 90 professors, researchers, MIT staff, and students attended.

Several PIs reported that their seed grants have catalyzed important new directions in their research that would not have been available without J-WAFS funding. For example, J-WAFS seed funding has allowed Professor Polz to apply his research on the environmental influences of microbial populations to the development of an antidote to the spread of disease in oyster aquaculture. Karthish Manthiram, a new assistant professor in ChemE, is applying his expertise in clean energy to the food sector for the first time as a result of a J-WAFS grant. J-WAFS seed funds are supporting his research on producing ammonia fertilizer from water and air using solar power. Several other PIs also noted how J-WAFS seed grants have helped them to secure substantial follow-on funding. Levi, Zaman, and Zheng credited their J-WAFS seed grant for providing a foundation that allowed them to bring in a multi-million-dollar award from the Walmart Foundation for their project on food safety and supply chains.

### **J-WAFS Research Speed Dating, October 2017**

In association with the call for proposals for its seed research funding, J-WAFS hosts an annual “research speed dating” event that exposes prospective applicants to other food- and water-related research interests around the Institute. With a focus on interdisciplinary exchange, the event seeks to facilitate potential collaborations among faculty from different departments and disciplines, and, more generally, to expand awareness of water and food research being conducted by MIT researchers.

Twelve researchers representing four of the five schools at MIT—Engineering, Science, Architecture and Planning, and Humanities, Arts, and Social Sciences—attended the event where each presented new research project briefs and fielded questions.

### **Water Management for Future Climate Scenarios, January 31, 2018**

J-WAFS convened an interdisciplinary panel of five MIT graduate students and postdoctoral associates to introduce their research on water management challenges associated with climate change. Forty people attended, including MIT community members and members of the public, to hear presentations about constructed wetlands specially designed for maximized stormwater filtration and ecosystem support; a database that uses water impact information from multinational companies to spur more accurate water risk assessments; and a decision tool for water planners to use when evaluating how, when, and at what scale to build water infrastructure in the face of climate uncertainty. Presenters included Tyler Swingle MArch '18, Julian Koelbel, Sloan postdoctoral associate; Cristina Logg, DUSP master's degree candidate in city planning; and Sarah Fletcher, J-WAFS graduate fellow. The panel was moderated by Janelle Heslop, CEE SM and Sloan MBA candidate.

## **Climate Change, Agriculture, Water, and Food Security: What We Know and Don't Know, May 2018**

One way that J-WAFS seeks to contribute to building knowledge at MIT and beyond is through its expert workshops. These are topic-specific one- to two-day events that leverage MIT's convening power, bringing together experts from across the globe, discussing critical global water and food challenges. The purpose is to apply the solutions-oriented mission that J-WAFS follows in its research grants in a symposium format, to enliven this familiar structure of academic research exchange and expert dialog and leverage it for future policy impact. Each expert workshop results in a report and executive summary that is freely available via the J-WAFS website.

J-WAFS produced the "Climate Change, Agriculture, Water, and Food Security: What We Know and Don't Know" workshop at the MIT Endicott House in Dedham, MA. The workshop—funded by an anonymous donation made available through the Office of the Vice President for Research—focused on expert review of the current understanding of the impacts of climate change on agriculture and food security. Both climate's impact on agriculture and agriculture's impact on climate were considered, including changes to water availability and food crop productivity, as well as greenhouse gas emissions driven by food production. The objective of the workshop was to identify what is known with confidence and to raise questions that should be a high priority for future research, culminating with published results focused on informing policy and setting the research agenda for future work.

The event was organized by a committee of MIT staff, faculty, and affiliated faculty, which included Co-director of the MIT Joint Program on the Science and Policy of Global Change and Senior Sloan Lecturer John Reilly, J-WAFS Visiting Scholar Chandra Madramootoo, Professor Solomon, Director Lienhard, and J-WAFS Executive Director Renee J. Robins '83. Attendees included 27 invited presenters and moderators as well as graduate student note-takers, staff, and the MIT community. The culminating report and executive summary will be developed during the summer of 2018. J-WAFS has hired Erwan Monier, principal research scientist at the MIT Joint Program on the Science and Policy of Global Change, as an affiliated researcher to oversee the report preparation.

## **Co-sponsored Events**

### **MIT Water Summit, November 2017**

MIT Water Club's annual Water Summit gathered 255 participants at MIT from academia, nonprofit organizations, industry, and government. The mission of this event is to explore current problems and potential solutions surrounding key water issues. A theme is selected each year and used as a lens through which to look at water sector challenges; this year's theme was the water-food nexus. The first day focused on water use in agriculture, opening with a keynote speech by Madramootoo. This was followed by a keynote from Rajiv Singh, managing director of Rabobank North America Wholesale. Panels on groundwater resources, surface water pollution, and how climate change and population growth contribute to the world's uncertain water future completed the first day. The second day addressed the complexities of protein production and consumption as it relates to issues of water supply, safety, and environmental sustainability. Water

management challenges and strategies for sustainable meat and seafood production were discussed in a final keynote speech and by two expert panels.

The Water Club also added a new opportunity for students—a water career panel and career networking session—where participants explored career pathways and received advice from mid-career water sector professionals. Select research projects from across the US were also featured in an evening poster session, including two J-WAFS-funded seed grant projects: Advancing Water and Food Sustainability through Improved Understanding of Uncertainties in Climate Change and Climate Variability; and Bacterial Viruses as Pathogen Control Agents in Aquaculture Systems. The summit's concluding panel focused on analyses on and recommendations for a path forward to secure a future with adequate food supply and clean water, addressing the role of the private and public sectors, technology, investment, and social and political factors in meeting these needs.

### **Xylem Day at MIT**

In FY2017 Xylem, Inc., a major international water technology company, signed a three-year agreement for sponsored research and additional J-WAFS support, becoming the first member of the J-WAFS Research Affiliate program. Xylem's support of various J-WAFS initiatives is detailed throughout this report. J-WAFS and Xylem have worked closely together since the start of the Research Affiliate agreement, and Xylem's enthusiasm for the partnership with MIT has only grown. As a sign of Xylem's satisfaction with the research partnership, the company decided to host its annual executives meeting at MIT, using this as an opportunity to learn more about MIT research that could have effects on various of Xylem's water utilities technologies across the world. J-WAFS was a key partner in programming the agenda and invited additional MIT students and faculty to network with Xylem executives throughout the day.

The opportunity proved to be significant for two MIT students in particular. MechE PhD candidate Hilary Johnson presented her J-WAFS-sponsored and Xylem-funded research project and connected with Xylem's chief technology officer Jay Iyengar, who offered her the opportunity to attend the 2018 Stockholm World Water Week and to travel to various Xylem facilities in FY2018 to get to know their work. J-WAFS graduate student fellow Tang presented his water sensor research which gained Xylem executives' interest and potential research support. Tang said that his affiliation with J-WAFS was critical to obtaining potential resource support.

The event ended with a reception and banquet at which Xylem presented its Excellence in Innovation Award.

### **MIT Water Night, March 22, 2018**

On World Water Day the MIT Water Club celebrated water research of all kinds with an art- and science-filled celebration in MIT's Walker Memorial. More than 300 MIT faculty, students, and staff joined youth, families, and adults from around the Boston metropolitan area to learn about water through hands-on demonstrations, multimedia art and film, a poster session, and a keynote lecture by NASA astronaut and professor at MIT's Department of Aeronautics and Astronautics, J. A. Hoffman.



Posters and projects were submitted by Boston-area students as well as citizen scientists, and the projects were voted on by a panel of judges. Ramchander won first prize in the water technology category for her work on the J-WAFS Solutions grant-supported xylem water filter. Also among the presenters was Andi Sutton, who showed her collaboratively produced public art project on the effects of sea level rise on Boston's coastal landscape.

This was the first time the Water Club incorporated art and film into Water Night. Because this approach was new to the organizing committee, Sutton provided mentorship during its production to the Water Club co-presidents Gualtiero Jaeger and Quantum Wei, EAPS and MechE PhD candidates respectively.

### **MIT Water Innovation Prize, April 4, 2018**

The MIT Water Club hosted the fourth annual MIT Water Innovation Prize, an event that is co-sponsored by J-WAFS and Xylem, Inc., among others. The event included a kick-off "generator dinner" in the fall to support the formation of student teams. Sixty first-round proposals were submitted (twice that of 2017), and nine final student teams competed for \$30,000 in cash awards. Finalist teams worked with mentors who supported their idea development and helped them formulate a final business plan and presentation.

Each team prepared a business plan and a five-minute pitch to present that evening. The business plans and pitches were reviewed by a panel of six water innovation and entrepreneurship experts from across the region. The judges selected three winning teams. The top winner received \$15,000, and the two second-place winners each received \$7,500, to help them build their research into a business.

The 2018 prize winners were:

- Oasis—a company developing a low-cost, novel, and simple device that enables anyone to test water for E. coli contamination—took first place
- Majik Water—a company developing a desiccant-based air-water harvester that will provide drinking water in arid regions—took second place
- Velaron—a company creating a smart sensor system to allow shrimp farmers to prevent die-offs related to water nutrient levels—took second place

### **Rabobank-MIT Food and Agribusiness Innovation Prize, May 2018**

J-WAFS co-sponsored the third annual Rabobank-MIT Food and Agribusiness Innovation Prize and coached the student leaders of MIT's Food and Agriculture Club that were involved in its planning and implementation. This event, modeled after the Water Club's Water Innovation Prize, is the premier innovation prize for student-developed food and agribusiness start-ups. It is sponsored by the Rabobank Group—one of the largest banks in the world that caters to food and agribusiness clients—which provided the cash awards as well as mentorship and opportunities for exposure.

Thirty first-round proposals were submitted and seven finalist teams competed for \$25,000 in awards. The business plans and five-minute pitches were reviewed by a panel

of judges, which included Rabobank representatives and Director Lienhard. The judges selected two winning teams; the top winner received \$15,000, and the second-place winner received \$10,000.

The 2018 prize winners were:

- Eat Well—a team of students from Harvard T. H. Chan School of Public Health and outside experts, who have made simple, low-cost meal kits to be sold in “food deserts”—took first place
- Context Insights—a team based on an MIT Sloan School of Management class project that has developed a plan to crowdsource crop-price predictions from smallholder farmers in Africa and aggregate that data for governments and microfinance institutions to increase crop investments that alleviate market volatility—took second place

### **Climate Change and Crop Variability, May 10, 2018**

J-WAFS and EAPS brought David S. Battisti, who holds the Tamaki Endowed Chair of Atmospheric Sciences at the University of Washington, to talk with members of the MIT community about the potential impacts of climate change on future crop production. Forty MIT students, faculty, and staff attended.

### **SENSE.Nano: Environment, Water, and Agriculture, June 5, 2018**

J-WAFS and MIT’s Environmental Solutions Initiative (ESI) collaborated with SENSE.Nano to produce a daylong symposium focused on environment, water, and agriculture. The day included technical talks, presentations by MIT-launched start-ups, student-presented posters, and panel discussions that featured researchers funded by both J-WAFS and ESI. Director Lienhard presented a summary of the group’s mission and efforts as part of the day’s programming in addition to a panel on water, food, and agriculture that included Professor Swager’s J-WAFS Solutions project; a presentation of Karnik, Hart, and Vaishnav’s seed-grant-funded project; and the work of graduate fellow Tang. Executive Director Robins attended a SENSE.Nano board of directors meeting where she presented on the research in food and water sensing that J-WAFS supports at MIT.

## **Other**

### **Stockholm Junior Water Prize, June 2018**

J-WAFS sent two staff members, Jasmine Edo and Andi Sutton, to the US Stockholm Junior Water Prize competition in Charlotte, NC. Edo and Sutton were joined by Anselmo Cassiano, an MIT research affiliate who has taught courses through MIT’s D-Lab and is a member of the Water Club. The Stockholm Junior Water Prize is the world’s most prestigious award for youth-led water-related research. It was founded in 1997 by the Stockholm International Water Institute to cultivate a future generation of global water sector leaders.

MIT and J-WAFS became involved in the US Stockholm Junior Water Prize competition for the first time this year through the J-WAFS partnership with Xylem, Inc., which is a major sponsor of the prize competition. Edo, Sutton, and Cassiano volunteered their time as judges and coaches as 58 students from 47 US states and Puerto Rico presented their research competing for the US title and the opportunity to represent the US in the global Stockholm Junior Water Prize competition.

### **J-WAFS Personnel**

The core J-WAFS leadership team continues to include Director Lienhard and Executive Director Robins. Sutton continues in the position of communications and program manager.

Kenny Luu, financial coordinator in FY2017, departed for a position in the Research Laboratory for Electronics at MIT. J-WAFS expanded its financial support position to include program coordination and brought in Jasmine Edo—previously a research administrator from the Boston Children’s Hospital—in March 2018

To support expanded initiatives and outreach efforts, in FY2018 J-WAFS decided to add a full-time student position—communications and program assistant—and worked with Northeastern University’s cooperative program. Elia Knieriemen was hired in April and will start in the position in the beginning of July 2018. She is currently pursuing a bachelor’s degree in international affairs with a minor in food systems, sustainability, health, and equity at Northeastern University. J-WAFS has also been searching for a part-time staff member to assist with corporate engagement; there should be someone in the position by August 2018.

### **Visiting and Affiliated Researchers**

Madramootoo completed his second year as a visiting scholar with J-WAFS. In FY2018, he worked part time with J-WAFS for the May 2018 expert workshop “Climate Change, Agriculture, Water, and Food Security: What We Know and Don’t Know” planning committee. Before 2017, Madramootoo was dean of the School of Agricultural and Environmental Sciences at McGill University in Montreal, a professor in the Department of Bioresource Engineering, and director of the McGill University Water Innovation Laboratory.

In April 2018, Erwan Monier joined J-WAFS as an affiliated researcher. He took the lead role in preparing the public report on the May 2018 expert workshop; this is expected to be distributed and publicized during the fall of 2018.

**John H. Lienhard V**

**Director**

**Abdul Latif Jameel Professor of Water and Food**

**Renee J. Robins**

**Executive Director**